

Via E-mail

Mr. Jeff Robinson  
Branch Chief, Air Permits, Monitoring & Grants  
U.S. EPA Region 6, 6PD  
1201 Elm Street, Ste. 500  
Dallas, TX 75270

Re: Title V Application Incompleteness Determination  
Bluewater Texas Terminal LLC ("BWTX")

August 15, 2019

Dear Mr. Robinson:

BWTX is in receipt of your letter dated September 1, 2019, requesting additional information to complete the referenced air permit application.

This letter transmits BWTX's response to the additional information request.

I certify that, based on information and belief formed after reasonable inquiry, that the statements and information contained in these documents are true, accurate and complete.

If you have any additional questions regarding this application, please contact Ms. Chaitali Dave of Phillips 66 Company at [chaitali.r.dave@p66.com](mailto:chaitali.r.dave@p66.com) or 832-765-1069; or Dr. Jesse Lovegren of DiSorbo Consulting, LLC, at [jlovegren@disorboconsult.com](mailto:jlovegren@disorboconsult.com) or 512-961-4471.

Yours,



David Farris  
Vice President  
BWTT

Enclosure

## **Responses to Information Request**

*The information in the application appears to mirror the Bluewater Texas Terminal LLC (BWTT) Prevention of Significant Deterioration (PSD) application. Of special note, as the PSD application has been determined to be incomplete, much of the same information requested to make the PSD application complete will also be needed for the title V application to be considered complete.*

### **Response:**

Additional information was supplied on July 31, 2019, in response to the referenced completeness determination. A copy is enclosed.

1. *Please provide information on fugitive emissions as they should be included in the permit application in accordance with 40 CFR § 71.3(d).*

### **Response:**

The requested information is contained in Items 7 and 11 of the enclosed PSD application additional information submission.

2. *For the permitting record, please provide additional information to clarify how BWTT intends to verify that the noncompany owned, foreign flagship marine tank vessels loaded at BWTT are tested annually for a vapor tightness test in accordance with 40 CFR § 63.565(c).*

### **Response:**

BWTTX does not believe that 40 CFR § 63.565(c) is an applicable requirement. Notwithstanding, vapor tightness will be documented as a matter of course, as indicated below.

All marine tank vessels considered for loading at BWTTX will be screened by the P66 Vetting and Audit department against standardized vetting criteria, including the Oil Companies International Marine Forum (OCIMF) Ship Inspection Report (SIRE) Program. This vetting screening includes checks of the validity of all vessel Trading certificates, and specifically a verification of vapor tightness test and record of such, in accordance with 40 CFR § 63.565(c).

Additionally, BWTTX will verify vessel compliance with 40 CFR § 63.565(c) by requesting the vessel's Master to warrant that the vessel has been tested for vapor tightness. This will be accomplished by:

1. Requiring from the vessel a completed pre-arrival information questionnaire, including a copy of the vapor tightness certification.
2. A verification of the vapor tightness certification upon arrival as part of the Declaration of Inspection (DoI) ship / terminal interface, conforming to 46 CFR § 35.35-30.

The Vapor recovery system is approved by the flag State, is considered part of the Inert Gas system, and is required to be tested every time the IGS system is tested but at least annually.



Via E-mail

Mr. Jeff Robinson  
Branch Chief, Air Permits, Monitoring & Grants  
U.S. EPA Region 6, 6PD  
1201 Elm Street, Ste. 500  
Dallas, TX 75270

Re: New Source Review Air Permit Application Completeness Determination  
Bluewater Texas Terminal LLC ("BW\*TX")

July 31, 2019

Dear Mr. Robinson:

BW\*TX is in receipt of your letter dated June 28, 2019, requesting additional information to complete the referenced air permit application.

This letter transmits BW\*TX's response to the additional information request.

I certify that, based on information and belief formed after reasonable inquiry, that the statements and information contained in these documents are true, accurate and complete.

If you have any additional questions regarding this application, please contact Ms. Chaitali Dave of Phillips 66 Company at [chaitali.r.dave@p66.com](mailto:chaitali.r.dave@p66.com) or 832-765-1069; or Dr. Jesse Lovegren of DiSorbo Consulting, LLC, at [jlovegren@disorboconsult.com](mailto:jlovegren@disorboconsult.com) or 512-961-4471.

Yours,

A handwritten signature in black ink, appearing to read "David Farris", is written over a light blue horizontal line.

David Farris  
Vice President  
BW\*TX

Enclosure

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## Responses to Items

1. *Please provide additional supporting technical documentation to allow for the verification of the basis for the emission calculations. Specifically, the true vapor pressure of the crude oil (psia), molecular weight of vapors (lb/lb-mole), material composition data of the associated emissions (speciated) for the crude oil/condensate proposed for the export operation.*

### **Response:**

The nature of the requested supporting information is described in detail in Item 10, and a comprehensive response covering Items 1 and 10 is attached.

2. *The PSD permit application does not mention if there will be any emissions associated from startup, shutdown and maintenance activities. Does BWTT anticipate Maintenance, Startup and Shutdown (MSS) emissions from the marine loading project. EPA needs to ensure that these emissions are permitted, or they are unauthorized. Typically, EPA will permit these emissions by either establishing a separate alternative BACT that applies during MSS, or we may include the emissions into an emission point as part of our BACT determination for that unit with the expectation that the unit will meet BACT at all times. For the permitting record, please provide additional information regarding the facility's MSS emissions and BWTT's preference on how BACT for MSS emissions should be applied in the permit for the marine loading operation. Please be sure to include information for all operational scenarios detailing the startup and shutdown emissions.*

### **Response:**

BWTTX understands EPA's comment to be that excess emissions from MSS activities are unauthorized if not permitted.

BWTTX has not identified any MSS activities at the terminal that would result in emissions in excess of those expected during routine loading operations. Maintenance activities of the types that typically occur at terminals, such as pipeline pigging, meter proving, and pump maintenance, will take place at the onshore Booster station and will not give rise to emissions at the SPM terminal.

The maintenance activity with the highest potential emission rate that BWTTX has identified would be replacement of floating hoses, which would occur no more than once per year per hose string. As noted in the response to Item 7, hoses are flushed with seawater at the end of each loading operation, so hydrocarbons remaining in the hose would consist primarily of oil clinging to the elastomeric lining on the inner carcass. Emissions from draining of hoses during replacement is estimated by assuming that a volume of hydrocarbon liquids is volatilized and emitted to the air. The volume is estimated based on a clingage factor of  $0.006 \times 10^{-3}$  Bbl/ft<sup>2</sup>.<sup>1</sup> For a 600 mm I.D.  $\times$  1000' hose string, a total wetted area of 6184 ft<sup>2</sup> is calculated, corresponding to a clingage volume of 1.56 gallons,

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<sup>1</sup> AP-42 Chapter 7, Table 7.1-10.

or 11 lb for an assumed liquid density of 7.1 lb/gal. If this activity occurs at each of two hoses per buoy once per year, total annual emissions of 44 lb, or 0.02 tpy are expected.

To the extent that MSS activities occur at the terminal, they will not interfere with BWTX's ability to meet the proposed emission limitations and BACT requirements at all times.

3. *The PSD permit application does not provide a compliance monitoring strategy for the marine loading operation. EPA requests that BWTT propose a monitoring, recordkeeping and reporting strategy to ensure enforceability of the BACT requirements pursuant to 40 CFR 52.21(n).*

**Response:**

BWTX appreciates the suggestion, and supports the inclusion of monitoring, recordkeeping and reporting requirements in the PSD permit, since doing so will facilitate development of the Part 71 permit (cf. 40 CFR § 71.6(a)(3)(iii)(B)).

BWTX's preference is that the same set of work practice requirements apply in order to satisfy BACT requirements for VOC emissions and MACT requirements for HAP emissions. BWTX's has provided a suggested Notice of MACT Approval (NOMA) determination containing monitoring, recordkeeping and reporting requirements, and BWTX requests that such NOMA requirements be used to establish monitoring, recordkeeping and reporting requirements for applicable requirements of the PSD permit. Please refer to Section 9 of the concurrently filed Case-by-case MACT application.

Given the information contained in this response, BWTX believes that the exact content of the work practice standard is subject to change (cf. response to Item 5), and BWTX also anticipates feedback from EPA on appropriate monitoring and recordkeeping mechanisms. BWTX will be happy to supply suggested monitoring conditions once it receives feedback from EPA on the work practices and monitoring mechanisms discussed elsewhere in this submission.

4. *The 5-Step BACT analysis provided does not differentiate between which control technologies will reduce VOC or GHG emissions or both. Please identify the Best Available Control Technology control options for both pollutants. The application lacks a GHG BACT analysis that evaluates GHG specific control technologies. The GHG BACT analysis should focus on those technologies that are specific to reducing GHG emissions. While some VOC control technologies also control GHG emissions, there are some control technologies focused on reducing GHG emissions that are not normally evaluated when performing a VOC BACT analysis. Please update the application to document the GHG specific control technology or operational practices that were considered.*

**Response:**

In light of the information supplied in response to Item 12, BWTX believes that GHG BACT requirements no longer apply.

As discussed in the response to Item 12, when estimated CO<sub>2</sub> emissions (produced by the vessel's inert gas generation system) of 17453 tpy CO<sub>2</sub>e are considered (cf. application

table 3-1), the potential to emit for GHG is less than 75,000 tpy on a CO<sub>2</sub>e basis, and GHG BACT requirements no longer apply.

5. *The 5-Step BACT analysis for VOC and GHG emissions does not include Best Management Practices for the SPM buoy system. Starting on page 4-4 of the permit application, a 5-step BACT analysis is provided for the VOC and GHG emissions associated with the proposed facility. The first step of the analysis is to identify all “available” control options for the emission unit, process or activity. A VOC Management Plan is included in the analysis. However, the VOC Management Plan is a ship-specific management plan that is required by the Regulation 15.6 of the International Convention for the Prevention of Pollution from Ships, Annex VI and is carried on-board tankers carrying crude oil. This plan is unique to the tanker and does not cover any Best Management Practices for the operation and maintenance of a SPM buoy system. The Best Management Practices for a SPM buoy system should include an effective plan for ship/shore interface, cargo transfer operations (i.e., minimizing gas formation in cargo tanks), maintenance (i.e., pigging), environmental (i.e., LDAR program), safety and health considerations and emergency preparedness. Please update the application to document the Best Management Practices for the SPM buoy system.*

**Response:**

BWTX agrees with EPA that a VOC Management Plan is distinct from a terminal operator’s Best Management Practices plan. However, unlike most traditional sources of air pollution, loading emissions result from the activities that a vessel engages in which directly serve the purposes of the terminal. Air emissions are ultimately emitted from the tanker vessel’s mast risers, and the emission rate is affected by measures implemented by the vessel operator under a VOC Management Plan.

BWTX agrees with EPA that there are practices undertaken by the terminal operator (or by the terminal operator in coordination with the vessel operator) which can serve to reduce the formation of VOC emissions during loading operations. Specifically, BWTX will employ standardized procedures for cargo transfer operations (ship/shore interface and pigging are not particularly relevant to air emissions for the specific installation).

BWTX will develop a deepwater port operations manual, and is required to conduct transfer operations in accordance with the manual pursuant to 33 CFR § 150.425. The operations manual will include the following requirements (cf. 33 CFR § 156.120):

- Each part of the transfer system is aligned to allow the flow of oil;
- Each part of the transfer system not necessary for the transfer operation is securely blanked or shut off;
- The end of each hose not connected for the transfer of oil is blanked off;
- Prior to transfer, a conference is held which ensures that each person in charge understands the sequence of transfer operations, the transfer rate, and critical stages of the transfer operation;

- Transfer does not occur until the terminal operator and person in charge of the receiving vessel agree to begin the transfer operation;
- The transfer rate is reduced at the start of the load to while ensuring proper hose connections, valve line-ups and piping integrity, and at the end of the load to minimize the risk of pressure surges and overfilling.

These aspects of the operations manual serve to reduce the formation of VOC vapors in the transfer lines and vessel cargo tanks.

BWTX appreciates EPA's suggestion about incorporating elements of the terminal's Best Management Practices into the BACT determination, and requests that compliance with the deepwater port operations manual be included as an element of the proposed combined work practice standard.

A draft Best Management Practices plan and a draft Operations Manual may be found in Vol. II, Appendix V, and Vol. III, Appendix A of BWTX's Deepwater Port license application.

6. *The VOC BACT analysis does not appear to include any best management practices to reduce the gas formation in the cargo tanks. The amount and concentration of gas formation depends of several factors including the True Vapor Pressure (TVP) of the cargo; amount of splashing as the oil enters the tank; time required to load the tank; and, the occurrence of a partial vacuum in the loading line. Please update the application to document the Best Management Practices for controlling VOCs.*

**Response:**

Please see the response to Item 5.

BWTX additionally notes that the majority of the practices identified in this Item are in control of the vessel operator. Consistent with the terminal's operations manual, the vessel operator, in coordination with the onboard mooring master and shoreside operator, dictates the transfer rate during the loading operation.

7. *The PSD permit application does not appear to include a VOC annual emission estimate from fugitives nor does it include a five-step BACT analysis. Please provide an estimate of fugitive emissions and a 5-step BACT analysis for fugitive emissions associated with the pipeline and SPM components located in Federal waters. In this analysis, please include an evaluation of technologies considered to reduce fugitive emissions and a basis for elimination, or information detailing why fugitive emissions will not be emitted from this project. Please also include if the proposed fugitive monitoring program will include monitoring for methane (CH<sub>4</sub>). The technologies could include, but are not limited to, the following:*

*Installing leakless technology components to eliminate fugitive emission sources;*

*Implementing an alternative monitoring program using a remote sensing technology such as infrared camera monitoring;*

*Designing and constructing facilities with high quality components and materials of construction compatible with the process known as the Enhanced LDAR standards;*

*Monitoring of flanges for leaks;*

*Using a lower leak detection level for components; and*

*Implementing an audio/visual/olfactory (AVO) monitoring program for compounds.*

**Response:**

As discussed in the response to Item 11, uncontrolled fugitive emissions would be approximately 0.25 tpy VOC per buoy if SOCM average emission factors were used.

BWTX appreciates EPA's assistance in identifying candidate control technologies. These are referred to as options 1–6, respectively. An additional work practice, referred to as option 7, is also discussed below. Assumed control efficiencies are as follows:

Technology	Control Efficiency
Leakless Technology	100%
Remote Sensing Technology	Undefined
Enhanced LDAR—high quality component and materials of construction	Undefined
Instrumental Monitoring of flanges, including via optical gas imaging	75–97%
Lower Leak Detection Levels	Undefined
Implementing an audio/visual/olfactory (AVO) monitoring program for compounds	30%
Limit time in VOC service	50%

For the sake of argument, BWTX assumes that all control options are technically feasible. However, the vessel to transport the leak detection personnel would require specific clearance from the port operator before being allowed to operate in the safety zone if classified as a “support vessel,” and would otherwise be forbidden from anchoring in the safety zone or mooring to the SPM (33 CFR § 150.380). It is unlikely that such clearance would be granted during a loading operation, however. Monitoring would have to take place during periods when the terminal is idle and when piping components are not in VOC service.

The facility as currently designed employs high quality components which are substantially leakless, and will also employ remote sensing technologies to detect the presence of significant leaks.

Floating hoses are manufactured with leak free elastomeric linings on the inner carcass which prevent leaks of hydrocarbon liquids which might otherwise arise from connections in steel piping. The floating hoses are of double carcass design, such that any leaks forming from the inner carcass are contained.

Flanged connections occur at marine breakaway-dry couplings (MBC's) located at regular intervals along the floating hose. Marine breakaway couplings used in marine offshore oil terminals generally comprise of a unit joined in two halves incorporating a shut off valve(s) which requires no external power or control source to activate i.e. it is a passive device. The valve(s) are mechanically locked in the open position and fail safe to close when activated. The two halves of the unit will part on load/surge and separation initiates the closure of the valve(s). As the unit separates, flow of the liquid being transferred is stopped and contained within each part of the separated hose (where double closure units are fitted).<sup>2</sup>

The two aspects of floating hose design (leak free interior lining and MBC's) described in the previous paragraph provide complementary protection from small leaks that may occur during routine operations and from significant leaks and spills that could occur during incidents. BWTX believes that the SPM and floating hose flanges can be reasonably classified as "leakless" if installed and operated in accordance with the following requirements and guidelines.

- 33 CFR § 150.405, specifying testing and inspection requirements for floating hoses.
- 33 CFR § 149.650, requiring durability under combined wind, wave, and current forces of the most severe storm that can be expected to occur at the port in any 100-year period.
- OCIMF Guide to Purchasing, Manufacturing and Testing of Loading and Discharge Hoses for Offshore Moorings.
- OCIMF SPM Hose Ancillary Equipment Guide.

Remote sensing technology which can detect and locate leaks and other malfunctions will be installed at the deepwater port, as required under 33 CFR § 149.125.

At the end of each loading operation, the floating hoses will be flushed with sea water, with some sea water entering the tanker's slop oil tanks. This work practice serves to limit the amount of time that the floating hose connectors are in VOC service.

The use of leakless components, high quality construction materials, and remote sensing technologies (Options 1–3) is required under USCG regulations, and involves no additional marginal cost. These options have a marginal cost effectiveness of \$0/ton.

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<sup>2</sup> Oil Companies International Marine Forum (OCIMF). *Information Paper— Marine Breakaway Couplings*. November 2008.

Additionally, the work practice of inventorying floating hoses with sea water when idle (Option 7) has no marginal cost.

Regular monitoring of flanges for leaks using an FID, PID, or optical gas imaging device (options 4–5); or AVO inspections (option 6) would require chartering of a special-purpose vessel and employing skilled technicians to conduct the monitoring. The annualized cost of chartering and fueling the vessel and hiring the operator would be similar for all such options, regardless of the cost of monitoring instrumentation. BWTX believes that such costs would exceed \$20,000 per year. However, as noted above, inspections would not be permitted during loading operations, and could only take place when the terminal is idle (and the floating hoses are inventoried with sea water). The likelihood of successfully detecting a leak would be reduced, such that the generic control efficiencies cited above would not be realized. If a VOC reduction of 0.08–0.24 tons/yr were realized, it would correspond to a cost effectiveness of \$80,000–270,000/ton or greater.

When the technologies identified above are ranked by decreasing control effectiveness, the use of leakless technology is the top ranked option. BWTX does not propose to eliminate the top-ranked option based on energy, environmental or economic impacts.

Therefore, the use of leakless technology, combined with the work practice of inventorying hoses with seawater when idle, is proposed as BACT.

8. *The BACT analysis should include for the proposed monitoring program a compliance strategy (i.e., frequencies of inspections, maintenance repair strategy, recordkeeping, etc.) Please update the application to include a compliance strategy for the proposed monitoring program.*

**Response:**

The option identified as BACT in the response to Item 7 consists primarily of a required equipment design practice. Equipment design practices are not amenable to ongoing periodic monitoring or recordkeeping after initial compliance has been achieved. If EPA deems it appropriate, BWTX would consider compliance with 33 CFR § 150.405 as a reasonable condition for a PSD permit. BWTX also believes that a reasonable additional monitoring requirement could consist of an annotation in the operator's log indicating that the hose was inventoried with seawater at the conclusion of the loading operation.

9. *The technical infeasibility BACT review discussion in step 2 does not clearly document the technical feasibility difficulties of add on controls based on source-specific design factors and physical, chemical, and engineering principles that preclude the safe and successful use of the control options. Economic, energy, and environmental impacts (step 4 of the BACT analysis) do not influence the removal of a technology during the technical feasibility review in step 2 of the BACT analysis. Please update the application to supplement the technical infeasibility BACT review discussion.*

**Response:**

BWTX agrees that energy, environmental, and economic impacts do not influence the removal of a technology at step 2 of the top-down BACT process. However, BWTX questions whether step 2 of EPA's top-down BACT process is accurately characterized by the phrasing in this Item. BWTX believes that EPA intends to refer to step 2 in a shorthand manner, rather than require an evaluation not contemplated by the top-down BACT guidance.

At step 2, the top-down BACT guidance distinguishes between "availability" and "applicability" as follows:<sup>3</sup>

*Two key concepts are important in determining whether an undemonstrated technology is feasible: "availability" and "applicability." A technology is considered "available" if it can be obtained by the applicant through commercial channels or is otherwise available within the common sense meaning of the term. An available technology is "applicable" if it can reasonably be installed and operated on the source type under consideration. A technology that is available and applicable is technically feasible.*

The guidance therefore establishes a two-part test for determining whether an undemonstrated technology is technically feasible (and therefore must be considered at step 3). Conversely, the test implies that if a technology is not "available," it can be rejected without the need to determine whether it is "applicable."

The phrasing in this Item suggests that EPA would like a more detailed analysis as to whether each of the technologies identified in step 1 of the analysis is "applicable." With the preceding distinction in mind, BWTX would like to comment that the information presented in Section 4.3.3 of the application was primarily intended to demonstrate that the rejected technologies are not "available." BWTX assessed whether a control technology solution consisting of a capture system and final control device was available for each candidate technology.

The application (pp. 4-11–4-13) contains a discussion of factors limiting the "applicability" of the technology referred to as "Vapor recovery pipeline / PLEM." In addition to these, BWTX wishes to explicitly note that its specific source design does not include the construction of any offshore platform.

The application (p. 4-13) contains a discussion of the source-specific design and operational characteristics which distinguish the proposed facility from the offshore loading terminal in El Segundo, CA, where a recovery system onboard a workboat has been deployed. Such a system is not currently commercially available for the proposed terminal.

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<sup>3</sup> EPA Office of Air Quality Planning and Standards. March 15, 1990. *DRAFT "Top-Down" Best Available Control Technology Guidance Document* (henceforth "Top-down Guidance"). At 19.

Source-specific technical factors discussed in the application, each of which is essential to the terminal's basic business purpose, include differences in mooring geometry, sea/weather conditions, product volatility, and product pumping rate.

The application (pp. 4-13–4-14) states, with respect to the “recovery system onboard loaded vessel” technology, that the technology is commercially available, but only “*applicable in cases where the terminal can restrict the types of loaded ships to specially-designed vessels under the control of the terminal owner.*” The application demonstrates elsewhere, with detailed supporting information, that such a control system has only been deployed in such cases where the types of loaded ships are so restricted. BWTX believes that this source-specific design factor presents a compelling difference for finding that the solution is not “applicable.” One additional remark that may be relevant is the distinction between technologies that are “commercially available” and those that are “available” in the context of an applicant's basic business purpose. In the latter sense, the technology is clearly not “available.”

*The permit issuer (here, the Region) should take a “hard look” at the applicant's determination in order to discern which design elements are inherent for the applicant's purpose and which design elements “may be changed to achieve pollutant emissions reductions without disrupting the applicant's basic business purpose for the proposed facility,” while keeping in mind that BACT, in most cases, should not be applied to regulate the applicant's purpose or objective for the proposed facility.<sup>4</sup>*

As a final note, BWTX notes that the top-down guidance does not require for undemonstrated / innovative technologies to be listed at step 1.<sup>5</sup> BWTX elected to discuss, in the context of step 1 of its analysis (Sec. 4.3.2), technologies which might have otherwise been disregarded based on their unavailability / innovative nature. Based on the information presented in its application, BWTX feels that EPA could conclude that the control options eliminated at step 2 in the original analysis are more appropriately eliminated at step 1.

10. *The application only provides emissions in tons per year. The emissions are estimated using generic values. The emission calculations utilize data from VOC Emissions from Oil and Condensate Storage Tanks: Final Report. 2009. BWTT takes the average values from the data in the report to utilize in the emission calculations. This is done without providing a reasoned justification or scientific basis for using this data. In addition, there no basis is given for the assumptions made in using the average values. BWTT estimated emissions on the VOC species present in the 11 samples in the report instead of using the total hydrocarbons (including methane and ethane). The reasoning given was that the methane, ethane, nitrogen, and carbon dioxide in the crude oil would weather out before it is exported. Does BWTT have any data to support this reasoning? BWTT*

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<sup>4</sup> *In Re Desert Rock Energy Company, LLC*. 14 E.A.D. 484, 530. September 24, 2009. Internal citations omitted.

<sup>5</sup> Top-down Guidance at 13–14.

*should also provide documentation or reevaluate the H<sub>2</sub>S emissions and ensure that the value given is truly representative of the crude oil to be exported. Please provide an hourly emission estimate and calculate emissions based on known values for the crude oil you intend to export for all pollutants. Please use the entire range of speciated values providing a low end and high end value. In addition, will only crude oil be loaded or will condensate also be loaded? Please utilize available speciation data for emission calculations for the specific products being loaded.*

**Response:**

A detailed response is provided at the end of this submission.

11. *Please provide emission calculations for fugitive emissions for the pipeline and SPM components located in Federal waters.*

**Response:**

Pipeline and SPM components in Federal waters may include valves or flanges at the subsea pipeline, the PLEM, the underbuoy hoses, the SPM, and the floating hose. The PLEM and underbuoy hoses will contain flanged connections and actuated valves. However, BWTX does not believe that air emissions from submerged piping components are quantifiable, to the extent any will occur.

Each floating hose will have approximately 54 flanged connections, and each SPM buoy will have approximately 4 flanges on the exterior where hoses are connected. Typical emission factors used in air permitting were not developed based on sampling data from offshore loading connections. However, if SOCM average emission factor for flanges in light liquid service is used (0.0005 lb/hr/component),<sup>6</sup> then the uncontrolled emission rate is less than 0.06 lb/hr and 0.25 tpy VOC per buoy.

As noted in the response to Item 7, BWTX will employ leakless technology and a work practice of inventorying hoses with seawater during idle periods to eliminate fugitive emissions.

12. *If possible, please provide emission calculations for GHG emissions based on source specific data. If using source specific data is not feasible, please provide a detailed reasoning and justification for using the emission factors chosen in the application.*

**Response:**

BWTX appreciates the suggestion, and hereby revises its calculation for GHG emissions based on source specific data.

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<sup>6</sup> *Air Permit Technical Guidance for Chemical Sources. Fugitive Guidance. TCEQ Publication APDG 6422v2. June 2018. At 18.*

The analysis conducted in response to Item 10 contains estimates of methane emissions. Of the five samples evaluated, the LPG speciation analysis yielded detectable amounts of methane in one of the five samples. The LPG fraction of the sample contained 0.1 vol.% methane, corresponding to 0.00004964 wt.% methane in the liquid phase of the whole crude oil sample. When a suitable K-factor is applied and the liquid phase average molecular weight is considered, the vapor phase mass fraction of methane is estimated at 0.04 %. This corresponds to a methane mass emission rate of 7.2 tpy (180 tpy CO<sub>2</sub>e) based on the worst-case annual emission rate.

When estimated CO<sub>2</sub> emissions (produced by the vessel's inert gas generation system) of 17453 tpy CO<sub>2</sub>e are considered (cf. application table 3-1), the potential to emit for GHG is less than 75,000 tpy on a CO<sub>2</sub>e basis, and GHG BACT requirements no longer apply.

BWTX believes that this result is consistent with the original assumption that methane detected in crude oil at a production site would weather out by the time the crude oil reaches an export terminal (cf. Item 10).

13. *Table 5-1 in the PSD application identifies the maximum impact to land based receptors to be 1.6 ppb. This value is consistent with the results discussed in Appendix B, Ozone Analysis. However, the paragraph below table 5-1 states, "The project impact at the maximally impacted land-based receptor is 1.8 ppb...". Please verify which is the correct value.*

**Response:**

Thank you for drawing attention to this inconsistency. The correct value is 1.6 ppb.

14. *Section 3.7 of the Air Dispersion Modeling Report indicates that the receptor grid data was developed based on each of the single point mooring systems being surrounded by a circular "safety zone" and an additional circular "area to be avoided" making a composite circular boundary with radius of 1,350 meters around each of the central buoys. Please provide additional information regarding the difference between these areas, including what if any access the public may have within the areas. This information is necessary to determine if the ambient air has been appropriately represented within the modeling analysis.*

**Response:**

An Area to be Avoided (ATBA) is a "routeing [sic] measure comprising an area within defined limits in which either navigation is particularly hazardous or it is exceptionally important to avoid casualties and which should be avoided by all ships, or certain classes of ship."<sup>7</sup> ATBA's are recommendatory routing measures established via the IMO to promote safety of life and property, marine environmental protection, and navigation safety at deepwater ports and adjacent waters (33 CFR § 150.905). ATBA's are established by USCG regulation around each Deepwater Port and are marked on navigational charts.

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<sup>7</sup> *General Provisions on Ships' Routeing*. IMO Resolution A.572(14). Adopted November 20, 1985.

The activities of vessels are regulated within ATBA's; however, fishing, and the transit of vessels other than tanker or support vessels is not prohibited within an ATBA so long as communication is maintained with the person in charge of vessel operations (33 CFR § 150.380).

BWTX believes that EPA has discretion to exclude ATBA's from the definition of "ambient air" if appropriate conditions are met. Notwithstanding, however, BWTX has also determined that air quality impacts for the present project remain acceptable even if receptors are placed within the ATBA, up to the perimeter of the safety zone. Without prejudicing its position relating to ATBA's, BWTX suggests that EPA only exclude the safety zone from the definition of "ambient air" for the present demonstration, consistent with previous determinations.<sup>8</sup> The revised air dispersion modeling analysis (Cf. Item 18) incorporates receptors within the ATBA.

15. *Section 3.8 of the Air Dispersion Modeling Report states that due to missing dew point temperatures within the buoy data, the relative humidity values used in the meteorological data input file were obtained from the NSRDB website. Please provide additional information regarding the nature of data available from the NSRDB website. This information is necessary to determine if the NSRDB data is appropriate for use in an air dispersion modeling analysis. Also, please indicate why the SPM locations were chosen for data retrieval from the database instead of the location of meteorological stations from which the other meteorological parameters were taken.*

**Response:**

The National Solar Radiation Database (NSRDB) is a serially complete collection of hourly and half-hourly values of the three most common measurements of solar radiation—global horizontal, direct normal, and diffuse horizontal irradiance—and meteorological data. These data have been collected at a sufficient number of locations and temporal and spatial scales to accurately represent regional solar radiation climates. The data contributors include the National Renewable Energy Laboratory, U.S. Department of Energy, National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, and several university contributors.

The Physical Solar Model (PSM) was used to transform this data into a gridded format (4 km × 4 km segments) that is used to estimate solar radiation at any location within the United States for any time period after 1998 with as little as a 30-minute temporal resolution. PSM uses cloud properties from the satellite retrievals and then uses those properties to calculate surface radiation. More information is available here <https://nsrdb.nrel.gov/current-version#psm>.

All components of the selected meteorological data were selected based on their representativeness to meteorological conditions at the SPMs. Because the solar radiation

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<sup>8</sup> E.g., Steven Riva (R2) to Leon Sedefian (NYSDEC). October 9, 2007. *Re: Ambient Air for the Offshore LNG Broadwater Project.*

data was available at the SPM location, this data was selected because it was more representative of on-site conditions than they buoy locations.

16. *Please provide additional information to justify the use of 2013 met data from Buoy 42019 instead of from station PTAT2, which was used for 2014-2016 data, when Table 3-4 of the Air Dispersion Modeling Report indicates that the data completeness was the same for both locations. Please also provide information on whether there was consideration to utilize met data from one meteorological station for all 5 years and using data substitution from a nearby meteorological station only for missing data.*

**Response:**

Buoy 42019 is closer to the BWTT than PTAT2 and was the preferred source of meteorological data in cases where data capture doesn't favor PTAT2.

Originally, the PTAT2 meteorological data was obtained merely to fill in gaps within the data from Buoy 42019. However, significant amounts of information are missing from the 2014 and 2015 data sets for Buoy 42019. A hybrid data set for these periods may be irregularly disjointed. Such a hybrid data set is less likely to include persistent wind conditions— persistence could lead to higher concentrations for longer term averaging periods. In order to avoid artificially lowering concentrations for longer term averaging periods by using less persistent wind conditions, a single buoy was selected for each calendar year.

The other years of meteorology did not have significant data adequacy issues, but for each year the buoy with better data adequacy was selected for consistency. The exception, as noted, was for 2013. The data capture is identical for both sites for 2013, therefore Buoy 42019 was selected because it is closer to the Terminal.

17. *Section 5.2.3 of the PSD Application and 5.4 of the Air Dispersion Modeling Report indicated that the modeled impacts are acceptable even though the 1-hour ESL values for Crude Oil Vapor (<1% Benzene) are exceeded because the magnitude of exceedance falls within the acceptable range of 10 times the ESL over industrial waters. Please provide additional information regarding where the predicted exceedances occur that demonstrates that all modeled exceedances occur at locations that meet the definition of "industrial waters" as defined in the TCEQ's guidelines references in the PSD application. This information may include, but is not limited to, a plot showing the receptor locations with model predicted exceedances of the ESLs along with information to support a determination that the locations would be considered industrial waters.*

**Response:**

The TCEQ guidance in question provides in relevant part that:

*For the purposes of the effects evaluation of marine vessel facilities, a determination will be made on a case-by-case basis whether the adjacent water will be evaluated as industrial or recreational. In some evaluations, waters may not be specifically designated industrial or recreational during the review, but will be evaluated with*

*consideration for who is likely to be exposed to emissions from the marine vessel activities.*

BWTX notes that the determinations referred to in the TCEQ guidance are made by TCEQ Toxicologists. For the present permitting process, which falls under EPA's jurisdiction, it is uncertain what process EPA would use for making a determination as to whether certain receptors are located in "industrial waters" or "recreational waters" or whether it is more appropriate to avoid making a designation and instead considering the public's likelihood of exposure to emissions from the facility.

However, such a determination is no longer necessary under the revised impacts analysis prepared in response to Item 18. Impacts are acceptable regardless of whether off-property receptors are treated as "industrial waters" or as "recreational waters."

BWTX believes that the information request under this Item should be suspended pending review of the revised dispersion modeling analysis.

18. *The current State Health Effects Analysis only evaluates impacts for Crude Oil Vapors (<1% Benzene). Once the speciation data requested in Item 10 (above), has been obtained please update the analysis to address each of the speciated constituents that have corresponding ESL values.*

**Response:**

BWTX appreciates the suggestion, and has revised its State Health Effects Analysis accordingly.

AERMOD inputs were revised to extend the receptor grid inward to occupy the ATBA, and a unit emission rate was modeled for each SPM buoy. The worst-case 1-hr average impact corresponds to 4.31884  $\mu\text{g}/\text{m}^3$  per lb/hr and the worst-case annual average impact corresponds to 0.0177  $\mu\text{g}/\text{m}^3$  per tpy. The receptor with the highest impact occurs at the western edge of the safety zone surrounding buoy 1.  $\text{GLC}_{\text{MAX}}$  values for each constituent were determined by multiplying the worst-case hydrocarbon emission rate by the worst-case vapor phase mass fraction for the constituent.

For example, the  $\text{GLC}_{\text{MAX}}$  for Benzene was calculated as follows. The highest lb/hr hydrocarbon emission rate is 8007 lb/hr, and the highest vapor phase benzene mass fraction under the  $T=95^\circ\text{ F}$  condition is 0.35%. The worst-case benzene emission rate is therefore 28.20 lb/hr, corresponding to a worst-case impact of 121  $\mu\text{g}/\text{m}^3$ .

As noted in the response to Item 10, speciation data was obtained for five samples of crude oil which represent the range of products that BWTX intends to handle at the terminal. The total number of constituents positively identified in the samples ranged from 82–91. The vapor phase was estimated for each constituent and each sample, and an ESL was identified for each constituent from TCEQ's Toxicity Factor Database (henceforth "ESL list") for each constituent as well. In many cases, however, the ESL list specifies that a particular compound is surrogated to another for purposes of determining a screening factor. Thus, for example, *cis*-2-octene is surrogated to 1-octene and

*cis*-1,3-dimethylcyclohexane is surrogated to methylcyclohexane. Therefore, as a conservative measure, BWTX treated all “surrogate groups” consisting of a particular compound as well as all compounds surrogated to that compound as individual air contaminants for estimating emissions and evaluating impacts. The vapor phase mass fractions of all constituents belonging to the same surrogate group were summed for impacts evaluation purposes. A total of 26 surrogate groups were identified. Model results are provided in Appendix B-3 of this submission. The predicted off-property impacts at the worst-impacted off-property receptor are less than the applicable ESL for each constituent and averaging time.

Therefore, BWTX believes that emissions from the project are consistent with the intent of the Texas Clean Air Act.

Supporting documentation and calculations are presented in Appendix B of this response. Electronic modeling files may be found at the following link:

<https://disorboconsult.app.box.com/s/nueo3v5v1t3nfi774isfgtvan1ex88ga>

## Response to PSD Incompleteness Notification, Items 1 and 10

The response to this item is divided into two portions. First, BWTX briefly responds to the specific questions about the emissions calculation methodology presented in the application. Second, BWTX presents a proposed, revised emission calculation methodology.

### Methodological Remarks

The data in the referenced publication was selected because BWTX felt that it was methodologically apt: it was the only study identified providing comprehensive, directly measured data on the composition of vapors in the headspace of a crude oil storage tank. As EPA observes, however, several assumptions had to be made in order to use the data to develop emission factors. These assumptions were guided by two customary heuristics in developing emission calculations: first, assumptions should be scientifically-based, and should be conservative to the extent that their accuracy is not known; and second, they should be susceptible to verification in the form of permit monitoring requirements.

The mean was selected for several parameters for which multiple results were reported because these parameters were treated as random variables. A sample mean corresponds to the expected value of a random variable.

The solubility of gases in liquids is usually pressure-dependent, and not well-modeled by Raoult's law.<sup>1</sup> When the pressure of a system is suddenly reduced (e.g., when crude oils are removed from reservoirs), "weathering" or flash volatilization of gaseous compounds such as methane, ethane, carbon dioxide and nitrogen is expected. This intuition is consistent with the speciation data discussed below. Excluding these low-molecular weight compounds from the vapor phase molecular weight estimation was a conservative assumption which tended to increase reported emissions.

Basic assay data were compiled from fourteen crude oil samples representing the range of crude oils BWTX expects to handle. Reported dissolved H<sub>2</sub>S values range from 0–2 ppm, consistent with assumed value of 2 ppm used in the application.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14
H <sub>2</sub> S (ppm)	1	1	2	2	2	2	1	1	1	0	–	1	2	1

BWTX understands stabilized lease condensate to be a type of crude oil, when factors such as geologic reservoir and volatility are controlled for, and is unaware of any methodology for identifying a particular sample of unknown provenance as "crude oil" rather than "condensate." This understanding is reflected in the terms of the suggested NOMA. To answer EPA's specific question, BWTX does not currently plan to load condensate at the SPM terminal.

<sup>1</sup>J. H. Hildebrand. "Solubility." J. Am. Chem. Soc. 1916, 38(8) 1452–1473.

## Revised Methodology for Determining Speciated Emission Rates

In order to address EPA's request to "calculate emissions based on known values for the crude oil you intend to export for all pollutants," BWTX obtained detailed sampling data for five crude oil samples which are representative of the range of crude oils that BWTX expects to handle.

Data available for each sample included a boiling point distribution (ASTM D7169), a detailed hydrocarbon analysis (ASTM D7169 Appendix 1), relative densities of different cuts (various methods), and an analysis of the LPG cut (initial boiling point -70° F; ASTM D2163). The data provided detailed information on the liquid phase composition of a crude oil sample.

In order to estimate the composition of the vapors in equilibrium with each liquid sample, BWTX computed mole fractions for each constituent. Next, published K-factor nomographs<sup>2</sup> were used to determine equilibrium gas phase mole fractions of methane and ethane, and Raoult's law was used to determine gas phase partial pressures for all other constituents. Raoult's law was not used for methane and ethane because their respective critical temperatures may be exceeded at ambient conditions.

In order to determine the molecular weight of the crude oil sample as a whole, the molecular weight of each cut for which relative densities were reported was determined using the following published correlation,<sup>3</sup> where  $T_b$  is the middle boiling point of a petroleum fraction in Kelvins and  $d$  is the relative density of the cut.

$$MW = \frac{0.010770T_b^{1.52869+0.06486 \ln\left(\frac{T_b}{1078-T_b}\right)}}{d} \quad (1)$$

The proportion of the total sample corresponding to a particular cut, as well as the middle boiling point of each cut, was determined from boiling curves. For the LPG cut, the molecular weight was calculated directly from the speciation data mentioned above rather than from Goossens' correlation. The liquid phase average molecular weight is the harmonic mean of the molecular weights of the various cuts, weighted by their mass fractions.

Once mole fractions were calculated for each constituent reported in the detailed hydrocarbon analysis (the number of positively identified constituents ranged from 82-91), partial pressures were calculated for each constituent (excepting methane and ethane) using Raoult's law at two temperatures: 72.1° F (annual average) and 95° F (assumed worst-case hourly average). Pure component vapor pressures were calculated from Antoine equation coefficients downloaded from NIST Webbook. Where published coefficients were not identifiable, a structurally similar isomer was selected as a surrogate for purposes of determining vapor pressures.

Constituent-specific partial pressures and calculated  $y_i$  values for methane and ethane were used to develop a complete speciation of the vapor phase in equilibrium with the liquid phase of the sample, and thence to calculate the vapor phase molecular weight. Once the average vapor phase molecular weight was estimated, it was possible to determine the vapor phase mass fraction of each constituent. Additionally,

<sup>2</sup>Gas Processors Suppliers Association. 2004. Engineering Data Book (Sec. 25). Tulsa, OK.

<sup>3</sup>Goossens, Adriaan G. Prediction of Molecular Weight of Petroleum Fractions. Ind. Eng. Chem. Res. 1996, 35: 985-988.

partial pressures were summed to obtain a total vapor pressure and a total VOC vapor pressure for each sample and temperature (ten values total). Vapor phase molecular weights (lb/lbmol), VOC vapor pressures (psia), and emission rates (based on product throughputs and pumping rates represented in the application) are reported below for each sample and temperature condition.

Sample	1	2	3	4	5
MW (72.1° F)	59.37	57.07	56.89	53.04	55.94
MW (95° F)	60.32	58.09	57.75	53.57	56.79
HC VP (72.1° F)	5.24	3.37	4.59	6.44	4.55
HC VP (95° F)	7.74	4.94	6.74	9.32	6.67
VOC VP (72.1° F)	5.24	3.31	4.38	5.86	4.28
VOC VP (95° F)	7.74	4.83	6.36	8.28	6.18
HC ER (lb/hr)	7488	4607	6247	8007	6071
HC ER (tpy)	11767	7276	9859	12904	9611
VOC ER (lb/hr)	7488	4504	5892	7118	5632
VOC ER (tpy)	11767	7144	9407	11749	9051

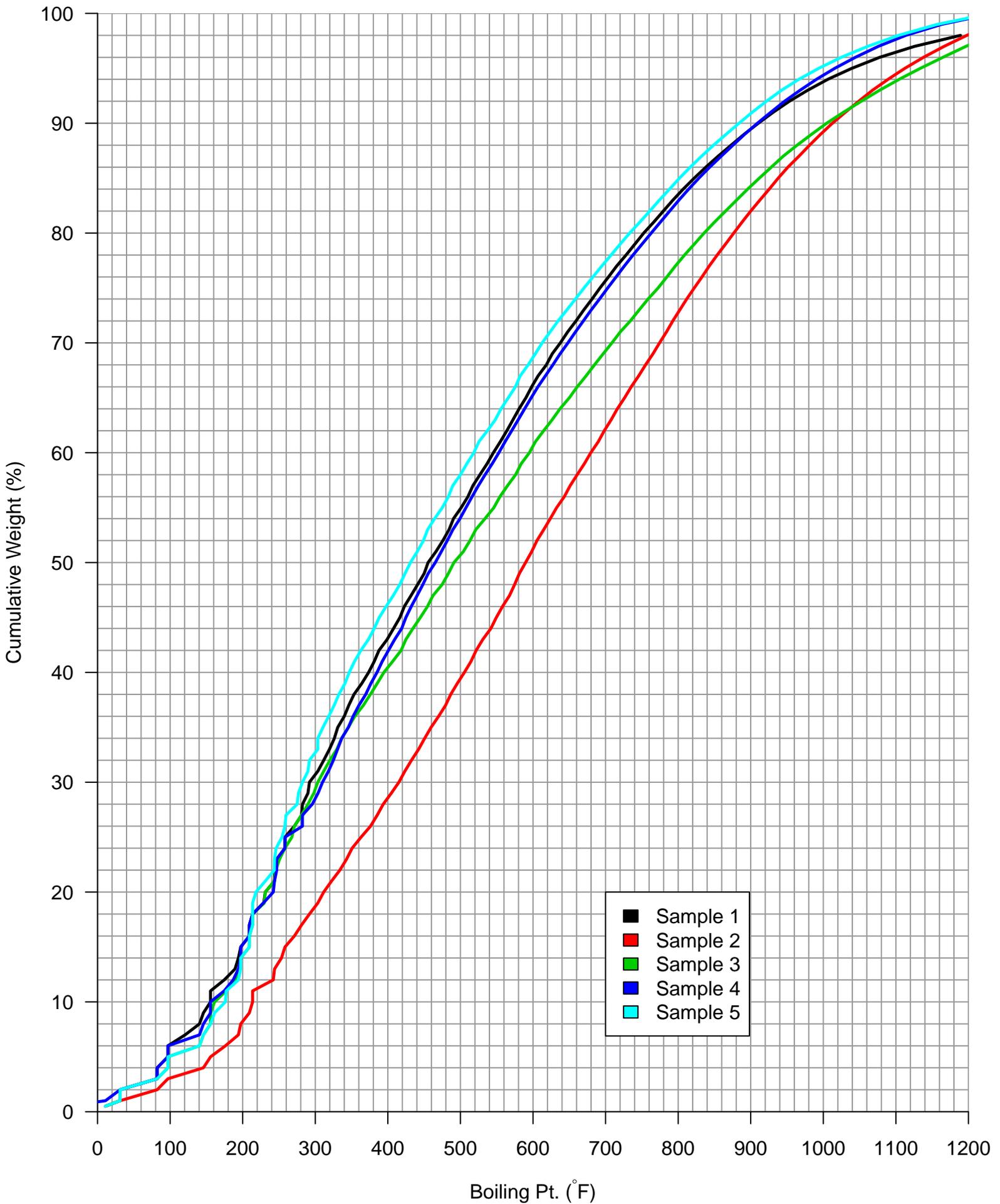
Vapor phase mass fractions for HAP constituents are summarized below for each sample at the T=95° F condition. Styrene was detected in only one sample. Isooctane, cresols, and naphthalene were not positively identified in any sample.

Sample	1	2	3	4	5
n-Hexane	3.20 %	3.09 %	3.57 %	3.13 %	3.57 %
Benzene	0.34 %	0.058 %	0.35 %	0.20 %	0.34 %
Toluene	0.19 %	0.13 %	0.28 %	0.13 %	0.33 %
m-Xylene	0.097 %	0.046 %	0.048 %	0.037 %	0.074 %
p-Xylene	0.049 %	0.056 %	0.034 %	0.028 %	0.043 %
o-Xylene	0.022 %	0.021 %	0.018 %	0.014 %	0.022 %
Ethylbenzene	0.011 %	0.017 %	0.027 %	0.011 %	0.021 %
Styrene	0.001 %	—	—	—	—

More detailed results, supporting calculations and figures are included as in Appendix A of this submission. While the results of this analysis generally support the assumptions originally made in the permit application, BWTX believes that EPA's preference is to use site-specific data to estimate emission rates, and requests that the source's potential to emit be updated based on the revised emission rates presented herein.

## Appendix A-1— Boiling Curves for Five Crude Oil Samples

# Boiling Curve



## Appendix A-2— Sample Calculation for Liquid Phase Molecular Weight Estimation

$$MW = g(T_b, d) = \frac{0.010770T_b^{1.52869+0.06486 \ln\left(\frac{T_b}{1078-T_b}\right)}}{d} \quad (2)$$

$$T/K = f(T/^{\circ}F) = \frac{T/^{\circ}F + 459.67}{1.8} \quad (3)$$

$$MW = g \circ (f \circ T_b, d) \quad (4)$$

Where:

$T_b$  = Middle boiling point of fraction (K) (from boiling curve)

$d$  = Relative density of fraction (dimensionless)

Cuts for which density data are available ( $^{\circ}F$ ):

IBP - 70  
70 - 155  
155 - 185  
185 - 210  
210 - 270  
270 - 335  
335 - 380  
380 - 450  
450 - 510  
510 - 580  
580 - 660  
660 - 785  
785 - 900  
900 - 1050  
1050 - FBP

For Sample 1,

$$\begin{array}{c}
 T_b / ^\circ F = \begin{bmatrix} - \\ 105.1 \\ 161.6 \\ 197.1 \\ 243.8 \\ 299.8 \\ 354.9 \\ 415.9 \\ 479.9 \\ 544.8 \\ 618.2 \\ 718.4 \\ 837.1 \\ 962.6 \\ 1166.2 \end{bmatrix}
 \end{array}$$

$$\begin{array}{c}
 d = \begin{bmatrix} - \\ 0.6494 \\ 0.6974 \\ 0.7172 \\ 0.7402 \\ 0.7614 \\ 0.7676 \\ 0.7780 \\ 0.7956 \\ 0.8095 \\ 0.8227 \\ 0.8418 \\ 0.8516 \\ 0.8649 \\ 0.8820 \end{bmatrix}
 \end{array}$$

$$\begin{array}{c}
 MW / \frac{\text{lb}}{\text{lbmol}} = \begin{bmatrix} MW_{\text{LPG}} = 58.9 \\ 78.0 \\ 88.0 \\ 95.9 \\ 107.2 \\ 122.6 \\ 141.6 \\ 163.9 \\ 188.3 \\ 216.5 \\ 252.8 \\ 309.9 \\ 298.3 \\ 518.4 \\ 832.1 \end{bmatrix}
 \end{array}
 \tag{5}$$

$MW_{\text{LPG}}$  is determined directly from the LPG analysis.

$$MW_{avg} = \left( \frac{\sum_{i=1}^n w_i MW_i^{-1}}{\sum_{i=1}^n w_i} \right)^{-1} \tag{6}$$

$$\begin{array}{c}
 w / \%(\text{from boiling curve}) = \begin{bmatrix} 2.76 \\ 7.17 \\ 2.77 \\ 4.49 \\ 8.72 \\ 9.54 \\ 5.39 \\ 8.16 \\ 6.96 \\ 7.94 \\ 8.16 \\ 10.34 \\ 7.05 \\ 5.82 \\ 4.72 \end{bmatrix}
 \end{array}
 \tag{7}$$

$$MW = 156.7 \text{ lb/lbmol} \tag{8}$$

## Appendix A-3— Speciation Calculations

Sample 1, T=72.1° F

Average Molecular Weight		
Liquid Phase:	156.75	lb/lbmol
Vapor Phase:	59.37	lb/lbmol
Methane / Ethane		
Methane K:	167.10	
Methane Mass% Liq	0.00000000	%
Methane $y_i$	0.00	ppm
Methane Mass% Vap	0.00000000	%
Ethane K:	28.63	
Ethane $p_i$ :	0.00	psia

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
n-butane	1.90000	0.05124	32.33790	1.65696	0.31595	30.93028
propane	0.32000	0.01137	128.84470	1.46558	0.27946	20.75558
i-butane	0.60000	0.01618	46.68395	0.75538	0.14404	14.10059
i-pentane	1.85000	0.04019	12.06945	0.48509	0.09250	11.24029
n-pentane	2.17000	0.04714	8.94467	0.42168	0.08041	9.77108
n-hexane	2.15000	0.03911	2.59458	0.10146	0.01935	2.80818
2-methylpentane	1.36000	0.02474	3.65310	0.09037	0.01723	2.50103
3-methylpentane	0.86000	0.01564	3.27061	0.05116	0.00976	1.41594
n-heptane	2.04000	0.03191	0.77018	0.02458	0.00469	0.79093
cyclopentane	0.25000	0.00559	5.50431	0.03075	0.00586	0.69273
2-methylhexane	0.94000	0.01470	1.11769	0.01643	0.00313	0.52889
methylcyclohexane	1.30000	0.02075	0.78425	0.01628	0.00310	0.51323
3-methylhexane	0.90000	0.01408	1.04376	0.01469	0.00280	0.47289
methylcyclopentane	0.38000	0.00708	2.35878	0.01669	0.00318	0.45122
cyclohexane	0.52000	0.00968	1.66588	0.01613	0.00308	0.43608
2,2-dimethylbutane	0.10000	0.00182	5.54852	0.01009	0.00192	0.27932
toluene	1.11000	0.01888	0.47674	0.00900	0.00172	0.26639
n-octane	1.76000	0.02415	0.23106	0.00558	0.00106	0.20472
benzene	0.20000	0.00401	1.61828	0.00649	0.00124	0.16293
2-methylheptane	0.84000	0.01153	0.34326	0.00396	0.00075	0.14515
3-methylheptane	0.73000	0.01002	0.34326	0.00344	0.00066	0.12614
2,4-dimethylpentane	0.14000	0.00219	1.68004	0.00368	0.00070	0.11840
2,2-dimethylpropane	0.01000	0.00022	22.76363	0.00495	0.00094	0.11459
2,3-dimethylpentane	0.18000	0.00282	1.17057	0.00330	0.00063	0.10607
1t,3-dimethylcyclopentane	0.14000	0.00223	1.28929	0.00288	0.00055	0.09086
1t,2-dimethylcyclopentane	0.13000	0.00208	1.28929	0.00268	0.00051	0.08437
2,2-dimethylpentane	0.09000	0.00141	1.79972	0.00253	0.00048	0.08154
1,3-dimethylbenzene	1.03000	0.01521	0.13786	0.00210	0.00040	0.07148
2,2,3-trimethylpentane	0.16000	0.00220	0.83572	0.00183	0.00035	0.06731

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
1c,3-dimethylcyclopentane	0.08000	0.00128	1.28929	0.00165	0.00031	0.05192
2,2,3-trimethylhexane	0.53000	0.00648	0.18914	0.00123	0.00023	0.05046
4-methylheptane	0.29000	0.00398	0.34223	0.00136	0.00026	0.04996
1c,2t,3-trimethylcyclopentane	0.35000	0.00489	0.26991	0.00132	0.00025	0.04756
n-nonane	1.60000	0.01955	0.05669	0.00111	0.00021	0.04566
1,1-dimethylcyclopentane	0.07000	0.00112	1.28929	0.00144	0.00027	0.04543
2,4-dimethylhexane	0.17000	0.00233	0.50803	0.00119	0.00023	0.04348
1,4-dimethylbenzene	0.49000	0.00723	0.14614	0.00106	0.00020	0.03605
3,3-dimethylpentane	0.05000	0.00078	1.41421	0.00111	0.00021	0.03560
1t,4-dimethylcyclohexane	0.16000	0.00223	0.26991	0.00060	0.00012	0.02174
2,3-dimethylhexane	0.09000	0.00123	0.39143	0.00048	0.00009	0.01773
1,2-dimethylbenzene	0.29000	0.00428	0.10833	0.00046	0.00009	0.01581
1c,2c,3-trimethylcyclopentane	0.11000	0.00154	0.26991	0.00041	0.00008	0.01495
i-propylcyclopentane	0.11000	0.00154	0.26991	0.00041	0.00008	0.01495
1c,2-dimethylcyclohexane	0.12000	0.00168	0.24055	0.00040	0.00008	0.01453
3,3-dimethylhexane	0.06000	0.00082	0.47758	0.00039	0.00007	0.01443
2,2-dimethylhexane	0.05000	0.00069	0.57233	0.00039	0.00007	0.01441
3-methyloctane	0.48000	0.00587	0.05669	0.00033	0.00006	0.01370
2-methyloctane	0.47000	0.00574	0.05669	0.00033	0.00006	0.01341
4-methyloctane	0.35000	0.00428	0.05669	0.00024	0.00005	0.00999
1,1-dimethylcyclohexane	0.07000	0.00098	0.26991	0.00026	0.00005	0.00951
2,5-dimethylheptane	0.32000	0.00391	0.05669	0.00022	0.00004	0.00913
2,2,3-trimethylbutane	0.01000	0.00016	1.75367	0.00027	0.00005	0.00883
ethylbenzene	0.10000	0.00148	0.15620	0.00023	0.00004	0.00786
2-methyl-3-ethylpentane	0.03000	0.00041	0.50948	0.00021	0.00004	0.00769
2,5-dimethylhexane	0.03000	0.00041	0.50948	0.00021	0.00004	0.00769
1c,2t,4-trimethylcyclopentane	0.05000	0.00070	0.26991	0.00019	0.00004	0.00679
3,4-dimethylhexane	0.03000	0.00041	0.36235	0.00015	0.00003	0.00547
1t,2c,3-trimethylcyclopentane	0.04000	0.00056	0.26991	0.00015	0.00003	0.00543
3-methyl-3-ethylpentane	0.02000	0.00027	0.38632	0.00011	0.00002	0.00389
2,3,5-trimethylhexane	0.03000	0.00037	0.18914	0.00007	0.00001	0.00286
4,4-dimethylheptane	0.10000	0.00122	0.05669	0.00007	0.00001	0.00285
2,2,5-trimethylhexane	0.02000	0.00024	0.27648	0.00007	0.00001	0.00278
3,3-diethylpentane	0.07000	0.00086	0.05669	0.00005	0.00001	0.00200
3,3-dimethylheptane	0.07000	0.00086	0.05669	0.00005	0.00001	0.00200
2,3,4-trimethylhexane	0.02000	0.00024	0.18914	0.00005	0.00001	0.00190
c-octene-2	0.01000	0.00014	0.28862	0.00004	0.00001	0.00145
1,1-methylethylcyclopentane	0.01000	0.00014	0.26991	0.00004	0.00001	0.00136
1c,3-dimethylcyclohexane	0.01000	0.00014	0.26991	0.00004	0.00001	0.00136
2t-ethylmethylcyclopentane	0.01000	0.00014	0.26991	0.00004	0.00001	0.00136
3c-ethylmethylcyclopentane	0.01000	0.00014	0.26991	0.00004	0.00001	0.00136
3t-ethylmethylcyclopentane	0.01000	0.00014	0.26991	0.00004	0.00001	0.00136
1c,2t,4t-trimethylcyclohexane	0.03000	0.00037	0.07721	0.00003	0.00001	0.00117
3,5-dimethylheptane	0.04000	0.00049	0.05669	0.00003	0.00001	0.00114

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
3,4-dimethylheptane	0.03000	0.00037	0.05669	0.00002	0.000004	0.00086
Styrene	0.01000	0.00015	0.10747	0.00002	0.000003	0.00054
1,1,2-trimethylcyclohexane	0.01000	0.00012	0.07721	0.00001	0.000002	0.00039
1c,2t,4c-trimethylcyclohexane	0.01000	0.00012	0.07721	0.00001	0.000002	0.00039
2,2-dimethylheptane	0.01000	0.00012	0.05669	0.00001	0.000001	0.00029
4-ethylheptane	0.01000	0.00012	0.05669	0.00001	0.000001	0.00029

Sample 1, T=95°F

Average Molecular Weight		
Liquid Phase:	156.75	lb/lbmol
Vapor Phase:	60.32	lb/lbmol
Methane / Ethane		
Methane K:	190.00	
Methane Mass% Liq	0.00000000	%
Methane $y_i$	0.00	ppm
Methane Mass% Vap	0.00000000	%
Ethane K:	35.50	
Ethane $p_i$ :	0.00	psia

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
n-butane	1.90000	0.05124	47.45453	2.43152	0.31417	30.27285
propane	0.32000	0.01137	176.65380	2.00940	0.25963	18.97994
i-butane	0.60000	0.01618	67.05331	1.08497	0.14018	13.50808
i-pentane	1.85000	0.04019	18.67352	0.75051	0.09697	11.59899
n-pentane	2.17000	0.04714	14.16178	0.66763	0.08626	10.31810
n-hexane	2.15000	0.03911	4.43665	0.17350	0.02242	3.20270
2-methylpentane	1.36000	0.02474	6.08944	0.15063	0.01946	2.78060
3-methylpentane	0.86000	0.01564	5.48122	0.08574	0.01108	1.58270
n-heptane	2.04000	0.03191	1.42681	0.04553	0.00588	0.97728
cyclopentane	0.25000	0.00559	8.96348	0.05008	0.00647	0.75238
2-methylhexane	0.94000	0.01470	2.01204	0.02959	0.00382	0.63502
methylcyclohexane	1.30000	0.02075	1.42286	0.02953	0.00382	0.62105
3-methylhexane	0.90000	0.01408	1.88579	0.02655	0.00343	0.56985
methylcyclopentane	0.38000	0.00708	4.03151	0.02853	0.00369	0.51437
cyclohexane	0.52000	0.00968	2.90982	0.02818	0.00364	0.50803
toluene	1.11000	0.01888	0.90368	0.01706	0.00220	0.33679
2,2-dimethylbutane	0.10000	0.00182	8.93253	0.01625	0.00210	0.29991
n-octane	1.76000	0.02415	0.46549	0.01124	0.00145	0.27507
benzene	0.20000	0.00401	2.86487	0.01150	0.00149	0.19238
2-methylheptane	0.84000	0.01153	0.66923	0.00771	0.00100	0.18875
3-methylheptane	0.73000	0.01002	0.66923	0.00670	0.00087	0.16403
2,4-dimethylpentane	0.14000	0.00219	2.93417	0.00643	0.00083	0.13792
2,3-dimethylpentane	0.18000	0.00282	2.08700	0.00588	0.00076	0.12613
2,2-dimethylpropane	0.01000	0.00022	33.79926	0.00734	0.00095	0.11348
1t,3-dimethylcyclopentane	0.14000	0.00223	2.27727	0.00509	0.00066	0.10704
1t,2-dimethylcyclopentane	0.13000	0.00208	2.27727	0.00473	0.00061	0.09940
1,3-dimethylbenzene	1.03000	0.01521	0.28049	0.00427	0.00055	0.09700
2,2-dimethylpentane	0.09000	0.00141	3.11782	0.00439	0.00057	0.09421
2,2,3-trimethylpentane	0.16000	0.00220	1.51201	0.00332	0.00043	0.08123
2,2,3-trimethylhexane	0.53000	0.00648	0.37895	0.00245	0.00032	0.06743
4-methylheptane	0.29000	0.00398	0.66709	0.00265	0.00034	0.06495

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
n-nonane	1.60000	0.01955	0.11691	0.00229	0.00030	0.06281
1c,2t,3-trimethylcyclopentane	0.35000	0.00489	0.52453	0.00256	0.00033	0.06164
1c,3-dimethylcyclopentane	0.08000	0.00128	2.27727	0.00291	0.00038	0.06117
2,4-dimethylhexane	0.17000	0.00233	0.96101	0.00224	0.00029	0.05485
1,1-dimethylcyclopentane	0.07000	0.00112	2.27727	0.00254	0.00033	0.05352
1,4-dimethylbenzene	0.49000	0.00723	0.29779	0.00215	0.00028	0.04899
3,3-dimethylpentane	0.05000	0.00078	2.47165	0.00193	0.00025	0.04149
1t,4-dimethylcyclohexane	0.16000	0.00223	0.52453	0.00117	0.00015	0.02818
2,3-dimethylhexane	0.09000	0.00123	0.75123	0.00093	0.00012	0.02270
1,2-dimethylbenzene	0.29000	0.00428	0.22572	0.00097	0.00012	0.02198
1c,2c,3-trimethylcyclopentane	0.11000	0.00154	0.52453	0.00081	0.00010	0.01937
i-propylcyclopentane	0.11000	0.00154	0.52453	0.00081	0.00010	0.01937
1c,2-dimethylcyclohexane	0.12000	0.00168	0.47036	0.00079	0.00010	0.01895
3-methyloctane	0.48000	0.00587	0.11691	0.00069	0.00009	0.01884
2-methyloctane	0.47000	0.00574	0.11691	0.00067	0.00009	0.01845
3,3-dimethylhexane	0.06000	0.00082	0.90338	0.00074	0.00010	0.01820
2,2-dimethylhexane	0.05000	0.00069	1.06869	0.00073	0.00009	0.01794
4-methyloctane	0.35000	0.00428	0.11691	0.00050	0.00006	0.01374
2,5-dimethylheptane	0.32000	0.00391	0.11691	0.00046	0.00006	0.01256
1,1-dimethylcyclohexane	0.07000	0.00098	0.52453	0.00051	0.00007	0.01233
ethylbenzene	0.10000	0.00148	0.31926	0.00047	0.00006	0.01072
2,2,3-trimethylbutane	0.01000	0.00016	3.01654	0.00047	0.00006	0.01013
2-methyl-3-ethylpentane	0.03000	0.00041	0.96528	0.00040	0.00005	0.00972
2,5-dimethylhexane	0.03000	0.00041	0.96528	0.00040	0.00005	0.00972
1c,2t,4-trimethylcyclopentane	0.05000	0.00070	0.52453	0.00037	0.00005	0.00881
1t,2c,3-trimethylcyclopentane	0.04000	0.00056	0.52453	0.00029	0.00004	0.00704
3,4-dimethylhexane	0.03000	0.00041	0.69690	0.00029	0.00004	0.00702
3-methyl-3-ethylpentane	0.02000	0.00027	0.73113	0.00020	0.00003	0.00491
4,4-dimethylheptane	0.10000	0.00122	0.11691	0.00014	0.00002	0.00393
2,3,5-trimethylhexane	0.03000	0.00037	0.37895	0.00014	0.00002	0.00382
2,2,5-trimethylhexane	0.02000	0.00024	0.54293	0.00013	0.00002	0.00365
3,3-diethylpentane	0.07000	0.00086	0.11691	0.00010	0.00001	0.00275
3,3-dimethylheptane	0.07000	0.00086	0.11691	0.00010	0.00001	0.00275
2,3,4-trimethylhexane	0.02000	0.00024	0.37895	0.00009	0.00001	0.00254
c-octene-2	0.01000	0.00014	0.57018	0.00008	0.00001	0.00191
1,1-methylethylcyclopentane	0.01000	0.00014	0.52453	0.00007	0.00001	0.00176
1c,3-dimethylcyclohexane	0.01000	0.00014	0.52453	0.00007	0.00001	0.00176
2t-ethylmethylcyclopentane	0.01000	0.00014	0.52453	0.00007	0.00001	0.00176
3c-ethylmethylcyclopentane	0.01000	0.00014	0.52453	0.00007	0.00001	0.00176
3t-ethylmethylcyclopentane	0.01000	0.00014	0.52453	0.00007	0.00001	0.00176
1c,2t,4t-trimethylcyclohexane	0.03000	0.00037	0.16373	0.00006	0.00001	0.00165
3,5-dimethylheptane	0.04000	0.00049	0.11691	0.00006	0.00001	0.00157
3,4-dimethylheptane	0.03000	0.00037	0.11691	0.00004	0.00001	0.00118
Styrene	0.01000	0.00015	0.22287	0.00003	0.000004	0.00075

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
1,1,2-trimethylcyclohexane	0.01000	0.00012	0.16373	0.00002	0.000003	0.00055
1c,2t,4c-trimethylcyclohexane	0.01000	0.00012	0.16373	0.00002	0.000003	0.00055
2,2-dimethylheptane	0.01000	0.00012	0.11691	0.00001	0.000002	0.00039
4-ethylheptane	0.01000	0.00012	0.11691	0.00001	0.000002	0.00039

Sample 2, T=72.1° F

Average Molecular Weight		
Liquid Phase:	189.92	lb/lbmol
Vapor Phase:	57.07	lb/lbmol
Methane / Ethane		
Methane K:	167.10	
Methane Mass% Liq	0.00004964	%
Methane $y_i$	982.09	ppm
Methane Mass% Vap	0.02760403	%
Ethane K:	28.63	
Ethane $p_i$ :	0.06	psia

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
propane	0.25000	0.01077	128.84470	1.38734	0.41877	32.35932
n-butane	0.74000	0.02418	32.33790	0.78194	0.23603	24.04011
i-butane	0.25000	0.00817	46.68395	0.38136	0.11511	11.72466
i-pentane	0.81000	0.02132	12.06945	0.25735	0.07768	9.82121
n-pentane	0.98000	0.02580	8.94467	0.23075	0.06965	8.80609
n-hexane	1.03000	0.02270	2.59458	0.05890	0.01778	2.68471
2-methylpentane	0.60000	0.01322	3.65310	0.04831	0.01458	2.20194
methylcyclopentane	0.70000	0.01580	2.35878	0.03726	0.01125	1.65874
3-methylpentane	0.38000	0.00837	3.27061	0.02739	0.00827	1.24855
methylcyclohexane	1.54000	0.02979	0.78425	0.02336	0.00705	1.21329
cyclohexane	0.64000	0.01444	1.66588	0.02406	0.00726	1.07107
cyclopentane	0.18000	0.00487	5.50431	0.02683	0.00810	0.99533
ethane	0.01000	0.00063		0.06101	0.01808	0.95284
n-heptane	1.04000	0.01971	0.77018	0.01518	0.00458	0.80467
3-methylhexane	0.43000	0.00815	1.04376	0.00851	0.00257	0.45088
2-methylhexane	0.36000	0.00682	1.11769	0.00763	0.00230	0.40422
1t,2-dimethylcyclopentane	0.31000	0.00600	1.28929	0.00773	0.00233	0.40152
1t,3-dimethylcyclopentane	0.22000	0.00426	1.28929	0.00549	0.00166	0.28495
1c,3-dimethylcyclopentane	0.19000	0.00368	1.28929	0.00474	0.00143	0.24609
n-octane	0.99000	0.01646	0.23106	0.00380	0.00115	0.22981
2,3-dimethylpentane	0.15000	0.00284	1.17057	0.00333	0.00100	0.17639
2-methylheptane	0.44000	0.00732	0.34326	0.00251	0.00076	0.15173
1,1-dimethylcyclopentane	0.10000	0.00193	1.28929	0.00249	0.00075	0.12952
1c,2t,3-trimethylcyclopentane	0.42000	0.00711	0.26991	0.00192	0.00058	0.11388
2,2,3-trimethylhexane	0.57000	0.00844	0.18914	0.00160	0.00048	0.10831
toluene	0.22000	0.00453	0.47674	0.00216	0.00065	0.10536
3-methylheptane	0.26000	0.00432	0.34326	0.00148	0.00045	0.08966
2,4-dimethylpentane	0.05000	0.00095	1.68004	0.00159	0.00048	0.08439
2,2-dimethylhexane	0.14000	0.00233	0.57233	0.00133	0.00040	0.08049
1c,2c,3-trimethylcyclopentane	0.25000	0.00423	0.26991	0.00114	0.00034	0.06779
2,2-dimethylbutane	0.01000	0.00022	5.54852	0.00122	0.00037	0.05574

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
n-nonane	0.94000	0.01392	0.05669	0.00079	0.00024	0.05354
1t,4-dimethylcyclohexane	0.19000	0.00322	0.26991	0.00087	0.00026	0.05152
benzene	0.03000	0.00073	1.61828	0.00118	0.00036	0.04877
n-propylcyclopentane	0.17000	0.00288	0.26991	0.00078	0.00023	0.04610
4-methylheptane	0.13000	0.00216	0.34223	0.00074	0.00022	0.04469
2,2,3-trimethylpentane	0.05000	0.00083	0.83572	0.00069	0.00021	0.04198
1,4-dimethylbenzene	0.28000	0.00501	0.14614	0.00073	0.00022	0.04111
2,5-dimethylhexane	0.08000	0.00133	0.50948	0.00068	0.00020	0.04095
2,4-dimethylhexane	0.08000	0.00133	0.50803	0.00068	0.00020	0.04083
2,2-dimethylpentane	0.02000	0.00038	1.79972	0.00068	0.00021	0.03616
1,3-dimethylbenzene	0.24000	0.00429	0.13786	0.00059	0.00018	0.03324
1c,2t,4-trimethylcyclopentane	0.12000	0.00203	0.26991	0.00055	0.00017	0.03254
1t,2c,3-trimethylcyclopentane	0.12000	0.00203	0.26991	0.00055	0.00017	0.03254
2-methyl-3-ethylpentane	0.06000	0.00100	0.50948	0.00051	0.00015	0.03071
2,3-dimethylhexane	0.06000	0.00100	0.39143	0.00039	0.00012	0.02359
2t-ethylmethylcyclopentane	0.08000	0.00135	0.26991	0.00037	0.00011	0.02169
i-propylcyclopentane	0.08000	0.00135	0.26991	0.00037	0.00011	0.02169
2,2,3-trimethylbutane	0.01000	0.00019	1.75367	0.00033	0.00010	0.01762
1c,2-dimethylcyclohexane	0.07000	0.00118	0.24055	0.00028	0.00009	0.01692
1,1-dimethylcyclohexane	0.06000	0.00102	0.26991	0.00027	0.00008	0.01627
1,2-dimethylbenzene	0.14000	0.00250	0.10833	0.00027	0.00008	0.01524
2,3,5-trimethylhexane	0.08000	0.00118	0.18914	0.00022	0.00007	0.01520
3,3-dimethylpentane	0.01000	0.00019	1.41421	0.00027	0.00008	0.01421
ethylbenzene	0.08000	0.00143	0.15620	0.00022	0.00007	0.01255
3-methyloctane	0.21000	0.00311	0.05669	0.00018	0.00005	0.01196
1c,2-dimethylcyclopentane	0.04000	0.00077	0.26991	0.00021	0.00006	0.01085
3-ethylhexane	0.03000	0.00050	0.33317	0.00017	0.00005	0.01004
2-methyloctane	0.17000	0.00252	0.05669	0.00014	0.00004	0.00968
3,3-dimethylhexane	0.02000	0.00033	0.47758	0.00016	0.00005	0.00960
4-methyloctane	0.15000	0.00222	0.05669	0.00013	0.00004	0.00854
3c-ethylmethylcyclopentane	0.03000	0.00051	0.26991	0.00014	0.00004	0.00813
3t-ethylmethylcyclopentane	0.03000	0.00051	0.26991	0.00014	0.00004	0.00813
3-methyl-3-ethylpentane	0.02000	0.00033	0.38632	0.00013	0.00004	0.00776
3,4-dimethylhexane	0.02000	0.00033	0.36235	0.00012	0.00004	0.00728
1,1-methylethylcyclopentane	0.02000	0.00034	0.26991	0.00009	0.00003	0.00542
2,5-dimethylheptane	0.09000	0.00133	0.05669	0.00008	0.00002	0.00513
2,6-dimethylheptane	0.02000	0.00030	0.18914	0.00006	0.00002	0.00380
c-octene-2	0.01000	0.00017	0.28862	0.00005	0.00001	0.00290
3,3-dimethylheptane	0.05000	0.00074	0.05669	0.00004	0.00001	0.00285
4-ethylheptane	0.05000	0.00074	0.05669	0.00004	0.00001	0.00285
2,2,5-trimethylhexane	0.01000	0.00015	0.27648	0.00004	0.00001	0.00278
1c,3-dimethylcyclohexane	0.01000	0.00017	0.26991	0.00005	0.00001	0.00271
1,1,4-trimethylcyclohexane	0.03000	0.00045	0.07721	0.00003	0.00001	0.00233
2,4,4-trimethylhexane	0.01000	0.00015	0.22259	0.00003	0.00001	0.00224

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
2,3,4-trimethylhexane	0.01000	0.00015	0.18914	0.00003	0.00001	0.00190
2,4-dimethylheptane	0.01000	0.00015	0.18914	0.00003	0.00001	0.00190
3,3-diethylpentane	0.03000	0.00044	0.05669	0.00003	0.00001	0.00171
1,1,3-trimethylcyclohexane	0.02000	0.00030	0.07721	0.00002	0.00001	0.00155
3,4-dimethylheptane	0.02000	0.00030	0.05669	0.00002	0.00001	0.00114
2,4-dimethylheptene-1	0.01000	0.00015	0.08699	0.00001	0.000004	0.00087
nonene-1	0.01000	0.00015	0.08699	0.00001	0.000004	0.00087
1,1,2-trimethylcyclohexane	0.01000	0.00015	0.07721	0.00001	0.000004	0.00078
1c,2t,4c-trimethylcyclohexane	0.01000	0.00015	0.07721	0.00001	0.000004	0.00078
3,5-dimethylheptane	0.01000	0.00015	0.05669	0.00001	0.000003	0.00057

Sample 2, T=95° F

Average Molecular Weight		
Liquid Phase:	189.92	lb/lbmol
Vapor Phase:	58.09	lb/lbmol
Methane / Ethane		
Methane K:	190.00	
Methane Mass% Liq	0.00004964	%
Methane $y_i$	1116.67	ppm
Methane Mass% Vap	0.03083285	%
Ethane K:	35.50	
Ethane $p_i$ :	0.11	psia

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
propane	0.25000	0.01077	176.65380	1.90213	0.39354	29.87280
n-butane	0.74000	0.02418	47.45453	1.14747	0.23740	23.75321
i-butane	0.25000	0.00817	67.05331	0.54776	0.11333	11.33896
i-pentane	0.81000	0.02132	18.67352	0.39816	0.08238	10.23114
n-pentane	0.98000	0.02580	14.16178	0.36533	0.07559	9.38765
n-hexane	1.03000	0.02270	4.43665	0.10071	0.02084	3.09105
2-methylpentane	0.60000	0.01322	6.08944	0.08052	0.01666	2.47139
methylcyclopentane	0.70000	0.01580	4.03151	0.06368	0.01318	1.90888
methylcyclohexane	1.54000	0.02979	1.42286	0.04238	0.00877	1.48216
3-methylpentane	0.38000	0.00837	5.48122	0.04590	0.00950	1.40888
cyclohexane	0.64000	0.01444	2.90982	0.04203	0.00869	1.25968
ethane	0.01000	0.00063		0.11086	0.02242	1.16063
cyclopentane	0.18000	0.00487	8.96348	0.04369	0.00904	1.09135
n-heptane	1.04000	0.01971	1.42681	0.02813	0.00582	1.00372
3-methylhexane	0.43000	0.00815	1.88579	0.01537	0.00318	0.54850
2-methylhexane	0.36000	0.00682	2.01204	0.01373	0.00284	0.48995
1t,2-dimethylcyclopentane	0.31000	0.00600	2.27727	0.01366	0.00283	0.47752
1t,3-dimethylcyclopentane	0.22000	0.00426	2.27727	0.00969	0.00200	0.33888
n-octane	0.99000	0.01646	0.46549	0.00766	0.00159	0.31172
1c,3-dimethylcyclopentane	0.19000	0.00368	2.27727	0.00837	0.00173	0.29267
2,3-dimethylpentane	0.15000	0.00284	2.08700	0.00593	0.00123	0.21175
2-methylheptane	0.44000	0.00732	0.66923	0.00490	0.00101	0.19918
1,1-dimethylcyclopentane	0.10000	0.00193	2.27727	0.00440	0.00091	0.15404
1c,2t,3-trimethylcyclopentane	0.42000	0.00711	0.52453	0.00373	0.00077	0.14902
2,2,3-trimethylhexane	0.57000	0.00844	0.37895	0.00320	0.00066	0.14611
toluene	0.22000	0.00453	0.90368	0.00410	0.00085	0.13448
3-methylheptane	0.26000	0.00432	0.66923	0.00289	0.00060	0.11770
2,2-dimethylhexane	0.14000	0.00233	1.06869	0.00249	0.00051	0.10120
2,4-dimethylpentane	0.05000	0.00095	2.93417	0.00278	0.00058	0.09924
1c,2c,3-trimethylcyclopentane	0.25000	0.00423	0.52453	0.00222	0.00046	0.08870
n-nonane	0.94000	0.01392	0.11691	0.00163	0.00034	0.07434

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
1t,4-dimethylcyclohexane	0.19000	0.00322	0.52453	0.00169	0.00035	0.06741
2,2-dimethylbutane	0.01000	0.00022	8.93253	0.00197	0.00041	0.06042
n-propylcyclopentane	0.17000	0.00288	0.52453	0.00151	0.00031	0.06032
4-methylheptane	0.13000	0.00216	0.66709	0.00144	0.00030	0.05866
benzene	0.03000	0.00073	2.86487	0.00209	0.00043	0.05814
1,4-dimethylbenzene	0.28000	0.00501	0.29779	0.00149	0.00031	0.05640
2,5-dimethylhexane	0.08000	0.00133	0.96528	0.00128	0.00027	0.05223
2,4-dimethylhexane	0.08000	0.00133	0.96101	0.00128	0.00026	0.05200
2,2,3-trimethylpentane	0.05000	0.00083	1.51201	0.00126	0.00026	0.05114
1,3-dimethylbenzene	0.24000	0.00429	0.28049	0.00120	0.00025	0.04553
1c,2t,4-trimethylcyclopentane	0.12000	0.00203	0.52453	0.00107	0.00022	0.04258
1t,2c,3-trimethylcyclopentane	0.12000	0.00203	0.52453	0.00107	0.00022	0.04258
2,2-dimethylpentane	0.02000	0.00038	3.11782	0.00118	0.00024	0.04218
2-methyl-3-ethylpentane	0.06000	0.00100	0.96528	0.00096	0.00020	0.03918
2,3-dimethylhexane	0.06000	0.00100	0.75123	0.00075	0.00016	0.03049
2t-ethylmethylcyclopentane	0.08000	0.00135	0.52453	0.00071	0.00015	0.02838
i-propylcyclopentane	0.08000	0.00135	0.52453	0.00071	0.00015	0.02838
1c,2-dimethylcyclohexane	0.07000	0.00118	0.47036	0.00056	0.00012	0.02227
1,2-dimethylbenzene	0.14000	0.00250	0.22572	0.00057	0.00012	0.02137
1,1-dimethylcyclohexane	0.06000	0.00102	0.52453	0.00053	0.00011	0.02129
2,3,5-trimethylhexane	0.08000	0.00118	0.37895	0.00045	0.00009	0.02051
2,2,3-trimethylbutane	0.01000	0.00019	3.01654	0.00057	0.00012	0.02040
ethylbenzene	0.08000	0.00143	0.31926	0.00046	0.00009	0.01728
3,3-dimethylpentane	0.01000	0.00019	2.47165	0.00047	0.00010	0.01672
3-methyloctane	0.21000	0.00311	0.11691	0.00036	0.00008	0.01661
1c,2-dimethylcyclopentane	0.04000	0.00077	0.52453	0.00041	0.00008	0.01419
2-methyloctane	0.17000	0.00252	0.11691	0.00029	0.00006	0.01344
3-ethylhexane	0.03000	0.00050	0.65042	0.00032	0.00007	0.01320
3,3-dimethylhexane	0.02000	0.00033	0.90338	0.00030	0.00006	0.01222
4-methyloctane	0.15000	0.00222	0.11691	0.00026	0.00005	0.01186
3c-ethylmethylcyclopentane	0.03000	0.00051	0.52453	0.00027	0.00006	0.01064
3t-ethylmethylcyclopentane	0.03000	0.00051	0.52453	0.00027	0.00006	0.01064
3-methyl-3-ethylpentane	0.02000	0.00033	0.73113	0.00024	0.00005	0.00989
3,4-dimethylhexane	0.02000	0.00033	0.69690	0.00023	0.00005	0.00943
2,5-dimethylheptane	0.09000	0.00133	0.11691	0.00016	0.00003	0.00712
1,1-methylethylcyclopentane	0.02000	0.00034	0.52453	0.00018	0.00004	0.00710
2,6-dimethylheptane	0.02000	0.00030	0.37895	0.00011	0.00002	0.00513
3,3-dimethylheptane	0.05000	0.00074	0.11691	0.00009	0.00002	0.00395
4-ethylheptane	0.05000	0.00074	0.11691	0.00009	0.00002	0.00395
c-octene-2	0.01000	0.00017	0.57018	0.00010	0.00002	0.00386
2,2,5-trimethylhexane	0.01000	0.00015	0.54293	0.00008	0.00002	0.00367
1c,3-dimethylcyclohexane	0.01000	0.00017	0.52453	0.00009	0.00002	0.00355
1,1,4-trimethylcyclohexane	0.03000	0.00045	0.16373	0.00007	0.00002	0.00332
2,4,4-trimethylhexane	0.01000	0.00015	0.43934	0.00007	0.00001	0.00297

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
2,3,4-trimethylhexane	0.01000	0.00015	0.37895	0.00006	0.00001	0.00256
2,4-dimethylheptane	0.01000	0.00015	0.37895	0.00006	0.00001	0.00256
3,3-diethylpentane	0.03000	0.00044	0.11691	0.00005	0.00001	0.00237
1,1,3-trimethylcyclohexane	0.02000	0.00030	0.16373	0.00005	0.00001	0.00221
3,4-dimethylheptane	0.02000	0.00030	0.11691	0.00003	0.00001	0.00158
2,4-dimethylheptene-1	0.01000	0.00015	0.18738	0.00003	0.00001	0.00127
nonene-1	0.01000	0.00015	0.18738	0.00003	0.00001	0.00127
1,1,2-trimethylcyclohexane	0.01000	0.00015	0.16373	0.00002	0.00001	0.00111
1c,2t,4c-trimethylcyclohexane	0.01000	0.00015	0.16373	0.00002	0.00001	0.00111
3,5-dimethylheptane	0.01000	0.00015	0.11691	0.00002	0.000004	0.00079

Sample 3, T=72.1° F

Average Molecular Weight		
Liquid Phase:	160.51	lb/lbmol
Vapor Phase:	56.89	lb/lbmol
Methane / Ethane		
Methane K:	167.10	
Methane Mass% Liq	0.00000000	%
Methane $y_i$	0.00	ppm
Methane Mass% Vap	0.00000000	%
Ethane K:	28.63	
Ethane $p_i$ :	0.21	psia

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
propane	0.39000	0.01420	128.84470	1.82911	0.41802	32.40233
n-butane	1.31000	0.03618	32.33790	1.16989	0.26737	27.31670
n-pentane	1.96000	0.04360	8.94467	0.39003	0.08914	11.30487
i-pentane	1.32000	0.02937	12.06945	0.35443	0.08100	10.27321
i-butane	0.28000	0.00773	46.68395	0.36098	0.08250	8.42890
n-hexane	1.84000	0.03427	2.59458	0.08892	0.02032	3.07844
2-methylpentane	1.04000	0.01937	3.65310	0.07076	0.01617	2.44985
ethane	0.03000	0.00160		0.21026	0.04585	2.42341
methylcyclopentane	1.05000	0.02003	2.35878	0.04724	0.01080	1.59706
3-methylpentane	0.75000	0.01397	3.27061	0.04569	0.01044	1.58174
cyclohexane	1.20000	0.02289	1.66588	0.03813	0.00871	1.28905
methylcyclohexane	2.13000	0.03482	0.78425	0.02731	0.00624	1.07715
cyclopentane	0.29000	0.00664	5.50431	0.03653	0.00835	1.02931
n-heptane	1.65000	0.02643	0.77018	0.02036	0.00465	0.81944
3-methylhexane	0.68000	0.01089	1.04376	0.01137	0.00260	0.45767
1t,2-dimethylcyclopentane	0.53000	0.00866	1.28929	0.01117	0.00255	0.44063
2-methylhexane	0.54000	0.00865	1.11769	0.00967	0.00221	0.38919
1t,3-dimethylcyclopentane	0.36000	0.00589	1.28929	0.00759	0.00173	0.29929
benzene	0.28000	0.00575	1.61828	0.00931	0.00213	0.29218
1c,3-dimethylcyclopentane	0.32000	0.00523	1.28929	0.00674	0.00154	0.26604
toluene	0.73000	0.01272	0.47674	0.00606	0.00139	0.22441
n-octane	1.33000	0.01869	0.23106	0.00432	0.00099	0.19817
2,3-dimethylpentane	0.20000	0.00320	1.17057	0.00375	0.00086	0.15096
2,2-dimethylbutane	0.04000	0.00075	5.54852	0.00413	0.00094	0.14311
2-methylheptane	0.64000	0.00899	0.34326	0.00309	0.00071	0.14166
1,1-dimethylcyclopentane	0.16000	0.00262	1.28929	0.00337	0.00077	0.13302
1c,2t,3-trimethylcyclopentane	0.58000	0.00830	0.26991	0.00224	0.00051	0.10095
2,2,3-trimethylhexane	0.71000	0.00889	0.18914	0.00168	0.00038	0.08659
3-methylheptane	0.36000	0.00506	0.34326	0.00174	0.00040	0.07968
2,2-dimethylhexane	0.21000	0.00295	0.57233	0.00169	0.00039	0.07750
1c,2c,3-trimethylcyclopentane	0.29000	0.00415	0.26991	0.00112	0.00026	0.05047

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
4-methylheptane	0.21000	0.00295	0.34223	0.00101	0.00023	0.04634
n-propylcyclopentane	0.26000	0.00372	0.26991	0.00100	0.00023	0.04525
2,2,3-trimethylpentane	0.08000	0.00112	0.83572	0.00094	0.00021	0.04311
1t,2c,3-trimethylcyclopentane	0.24000	0.00343	0.26991	0.00093	0.00021	0.04177
2,5-dimethylhexane	0.12000	0.00169	0.50948	0.00086	0.00020	0.03942
1t,4-dimethylcyclohexane	0.22000	0.00315	0.26991	0.00085	0.00019	0.03829
n-nonane	0.97000	0.01214	0.05669	0.00069	0.00016	0.03546
2,2-dimethylpentane	0.03000	0.00048	1.79972	0.00086	0.00020	0.03482
1c,2t,4-trimethylcyclopentane	0.20000	0.00286	0.26991	0.00077	0.00018	0.03481
1,3-dimethylbenzene	0.39000	0.00590	0.13786	0.00081	0.00019	0.03467
2-methyl-3-ethylpentane	0.10000	0.00141	0.50948	0.00072	0.00016	0.03285
2,4-dimethylhexane	0.10000	0.00141	0.50803	0.00071	0.00016	0.03276
1,4-dimethylbenzene	0.26000	0.00393	0.14614	0.00057	0.00013	0.02450
2t-ethylmethylcyclopentane	0.13000	0.00186	0.26991	0.00050	0.00011	0.02263
2,4-dimethylpentane	0.02000	0.00032	1.68004	0.00054	0.00012	0.02167
ethylbenzene	0.19000	0.00287	0.15620	0.00045	0.00010	0.01914
3,3-dimethylpentane	0.02000	0.00032	1.41421	0.00045	0.00010	0.01824
2,3-dimethylhexane	0.07000	0.00098	0.39143	0.00039	0.00009	0.01767
i-propylcyclopentane	0.09000	0.00129	0.26991	0.00035	0.00008	0.01566
3-ethylhexane	0.07000	0.00098	0.33317	0.00033	0.00007	0.01504
1,1-dimethylcyclohexane	0.08000	0.00114	0.26991	0.00031	0.00007	0.01392
1,2-dimethylbenzene	0.18000	0.00272	0.10833	0.00029	0.00007	0.01257
2,3,5-trimethylhexane	0.10000	0.00125	0.18914	0.00024	0.00005	0.01220
2,2,3-trimethylbutane	0.01000	0.00016	1.75367	0.00028	0.00006	0.01131
1c,2-dimethylcyclopentane	0.06000	0.00098	0.26991	0.00026	0.00006	0.01044
3c-ethylmethylcyclopentane	0.06000	0.00086	0.26991	0.00023	0.00005	0.01044
3-methyloctane	0.28000	0.00350	0.05669	0.00020	0.00005	0.01024
3,4-dimethylhexane	0.04000	0.00056	0.36235	0.00020	0.00005	0.00935
3,3-dimethylhexane	0.03000	0.00042	0.47758	0.00020	0.00005	0.00924
3t-ethylmethylcyclopentane	0.05000	0.00072	0.26991	0.00019	0.00004	0.00870
1c,2-dimethylcyclohexane	0.05000	0.00072	0.24055	0.00017	0.00004	0.00776
2-methyloctane	0.21000	0.00263	0.05669	0.00015	0.00003	0.00768
3-methyl-3-ethylpentane	0.03000	0.00042	0.38632	0.00016	0.00004	0.00747
4-methyloctane	0.17000	0.00213	0.05669	0.00012	0.00003	0.00621
2,4,4-trimethylhexane	0.03000	0.00038	0.22259	0.00008	0.00002	0.00431
2,5-dimethylheptane	0.11000	0.00138	0.05669	0.00008	0.00002	0.00402
1,1-methylethylcyclopentane	0.02000	0.00029	0.26991	0.00008	0.00002	0.00348
1,1,4-trimethylcyclohexane	0.06000	0.00076	0.07721	0.00006	0.00001	0.00299
2,3,4-trimethylhexane	0.02000	0.00025	0.18914	0.00005	0.00001	0.00244
2,4-dimethylheptane	0.02000	0.00025	0.18914	0.00005	0.00001	0.00244
2,6-dimethylheptane	0.02000	0.00025	0.18914	0.00005	0.00001	0.00244
3,3-dimethylheptane	0.06000	0.00075	0.05669	0.00004	0.00001	0.00219
1,1,3-trimethylcyclohexane	0.04000	0.00051	0.07721	0.00004	0.00001	0.00199
3,3-diethylpentane	0.05000	0.00063	0.05669	0.00004	0.00001	0.00183

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
4-ethylheptane	0.05000	0.00063	0.05669	0.00004	0.00001	0.00183
1c,3-dimethylcyclohexane	0.01000	0.00014	0.26991	0.00004	0.00001	0.00174
nonene-1	0.02000	0.00025	0.08699	0.00002	0.00001	0.00112
1c,2t,4c-trimethylcyclohexane	0.02000	0.00025	0.07721	0.00002	0.000004	0.00100
3,4-dimethylheptane	0.02000	0.00025	0.05669	0.00001	0.000003	0.00073
1,1,2-trimethylcyclohexane	0.01000	0.00013	0.07721	0.00001	0.000002	0.00050
3,5-dimethylheptane	0.01000	0.00013	0.05669	0.00001	0.000002	0.00037

Sample 3, T=95° F

Average Molecular Weight		
Liquid Phase:	160.51	lb/lbmol
Vapor Phase:	57.75	lb/lbmol
Methane / Ethane		
Methane K:	190.00	
Methane Mass% Liq	0.00000000	%
Methane $y_i$	0.00	ppm
Methane Mass% Vap	0.00000000	%
Ethane K:	35.50	
Ethane $p_i$ :	0.38	psia

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
propane	0.39000	0.01420	176.65380	2.50781	0.39423	30.10500
n-butane	1.31000	0.03618	47.45453	1.71676	0.26988	27.16440
n-pentane	1.96000	0.04360	14.16178	0.61752	0.09707	12.12900
i-pentane	1.32000	0.02937	18.67352	0.54837	0.08620	10.77088
i-butane	0.28000	0.00773	67.05331	0.51849	0.08151	8.20407
n-hexane	1.84000	0.03427	4.43665	0.15205	0.02390	3.56717
ethane	0.03000	0.00160		0.38344	0.05685	2.96035
2-methylpentane	1.04000	0.01937	6.08944	0.11796	0.01854	2.76733
methylcyclopentane	1.05000	0.02003	4.03151	0.08073	0.01269	1.84973
3-methylpentane	0.75000	0.01397	5.48122	0.07657	0.01204	1.79635
cyclohexane	1.20000	0.02289	2.90982	0.06660	0.01047	1.52580
methylcyclohexane	2.13000	0.03482	1.42286	0.04954	0.00779	1.32432
cyclopentane	0.29000	0.00664	8.96348	0.05949	0.00935	1.13586
n-heptane	1.65000	0.02643	1.42681	0.03771	0.00593	1.02873
3-methylhexane	0.68000	0.01089	1.88579	0.02054	0.00323	0.56034
1t,2-dimethylcyclopentane	0.53000	0.00866	2.27727	0.01973	0.00310	0.52740
2-methylhexane	0.54000	0.00865	2.01204	0.01740	0.00274	0.47477
1t,3-dimethylcyclopentane	0.36000	0.00589	2.27727	0.01340	0.00211	0.35824
benzene	0.28000	0.00575	2.86487	0.01648	0.00259	0.35052
1c,3-dimethylcyclopentane	0.32000	0.00523	2.27727	0.01191	0.00187	0.31843
toluene	0.73000	0.01272	0.90368	0.01149	0.00181	0.28826
n-octane	1.33000	0.01869	0.46549	0.00870	0.00137	0.27053
2-methylheptane	0.64000	0.00899	0.66923	0.00602	0.00095	0.18716
2,3-dimethylpentane	0.20000	0.00320	2.08700	0.00669	0.00105	0.18239
1,1-dimethylcyclopentane	0.16000	0.00262	2.27727	0.00596	0.00094	0.15922
2,2-dimethylbutane	0.04000	0.00075	8.93253	0.00666	0.00105	0.15613
1c,2t,3-trimethylcyclopentane	0.58000	0.00830	0.52453	0.00435	0.00068	0.13294
2,2,3-trimethylhexane	0.71000	0.00889	0.37895	0.00337	0.00053	0.11757
3-methylheptane	0.36000	0.00506	0.66923	0.00339	0.00053	0.10528
2,2-dimethylhexane	0.21000	0.00295	1.06869	0.00315	0.00050	0.09807
1c,2c,3-trimethylcyclopentane	0.29000	0.00415	0.52453	0.00218	0.00034	0.06647

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
4-methylheptane	0.21000	0.00295	0.66709	0.00197	0.00031	0.06121
n-propylcyclopentane	0.26000	0.00372	0.52453	0.00195	0.00031	0.05959
1t,2c,3-trimethylcyclopentane	0.24000	0.00343	0.52453	0.00180	0.00028	0.05501
2,2,3-trimethylpentane	0.08000	0.00112	1.51201	0.00170	0.00027	0.05286
2,5-dimethylhexane	0.12000	0.00169	0.96528	0.00163	0.00026	0.05062
1t,4-dimethylcyclohexane	0.22000	0.00315	0.52453	0.00165	0.00026	0.05042
n-nonane	0.97000	0.01214	0.11691	0.00142	0.00022	0.04955
1,3-dimethylbenzene	0.39000	0.00590	0.28049	0.00165	0.00026	0.04780
1c,2t,4-trimethylcyclopentane	0.20000	0.00286	0.52453	0.00150	0.00024	0.04584
2-methyl-3-ethylpentane	0.10000	0.00141	0.96528	0.00136	0.00021	0.04218
2,4-dimethylhexane	0.10000	0.00141	0.96101	0.00135	0.00021	0.04199
2,2-dimethylpentane	0.03000	0.00048	3.11782	0.00150	0.00024	0.04087
1,4-dimethylbenzene	0.26000	0.00393	0.29779	0.00117	0.00018	0.03383
2t-ethylmethylcyclopentane	0.13000	0.00186	0.52453	0.00098	0.00015	0.02980
ethylbenzene	0.19000	0.00287	0.31926	0.00092	0.00014	0.02651
2,4-dimethylpentane	0.02000	0.00032	2.93417	0.00094	0.00015	0.02564
2,3-dimethylhexane	0.07000	0.00098	0.75123	0.00074	0.00012	0.02298
3,3-dimethylpentane	0.02000	0.00032	2.47165	0.00079	0.00012	0.02160
i-propylcyclopentane	0.09000	0.00129	0.52453	0.00068	0.00011	0.02063
3-ethylhexane	0.07000	0.00098	0.65042	0.00064	0.00010	0.01989
1,1-dimethylcyclohexane	0.08000	0.00114	0.52453	0.00060	0.00009	0.01834
1,2-dimethylbenzene	0.18000	0.00272	0.22572	0.00061	0.00010	0.01775
2,3,5-trimethylhexane	0.10000	0.00125	0.37895	0.00047	0.00007	0.01656
3-methyloctane	0.28000	0.00350	0.11691	0.00041	0.00006	0.01430
1c,2-dimethylcyclopentane	0.06000	0.00098	0.52453	0.00051	0.00008	0.01375
3c-ethylmethylcyclopentane	0.06000	0.00086	0.52453	0.00045	0.00007	0.01375
2,2,3-trimethylbutane	0.01000	0.00016	3.01654	0.00048	0.00008	0.01318
3,4-dimethylhexane	0.04000	0.00056	0.69690	0.00039	0.00006	0.01218
3,3-dimethylhexane	0.03000	0.00042	0.90338	0.00038	0.00006	0.01184
3t-ethylmethylcyclopentane	0.05000	0.00072	0.52453	0.00038	0.00006	0.01146
2-methyloctane	0.21000	0.00263	0.11691	0.00031	0.00005	0.01073
1c,2-dimethylcyclohexane	0.05000	0.00072	0.47036	0.00034	0.00005	0.01028
3-methyl-3-ethylpentane	0.03000	0.00042	0.73113	0.00031	0.00005	0.00958
4-methyloctane	0.17000	0.00213	0.11691	0.00025	0.00004	0.00868
2,4,4-trimethylhexane	0.03000	0.00038	0.43934	0.00016	0.00003	0.00576
2,5-dimethylheptane	0.11000	0.00138	0.11691	0.00016	0.00003	0.00562
1,1-methylethylcyclopentane	0.02000	0.00029	0.52453	0.00015	0.00002	0.00458
1,1,4-trimethylcyclohexane	0.06000	0.00076	0.16373	0.00012	0.00002	0.00429
2,3,4-trimethylhexane	0.02000	0.00025	0.37895	0.00009	0.00001	0.00331
2,4-dimethylheptane	0.02000	0.00025	0.37895	0.00009	0.00001	0.00331
2,6-dimethylheptane	0.02000	0.00025	0.37895	0.00009	0.00001	0.00331
3,3-dimethylheptane	0.06000	0.00075	0.11691	0.00009	0.00001	0.00307
1,1,3-trimethylcyclohexane	0.04000	0.00051	0.16373	0.00008	0.00001	0.00286
3,3-diethylpentane	0.05000	0.00063	0.11691	0.00007	0.00001	0.00255

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
4-ethylheptane	0.05000	0.00063	0.11691	0.00007	0.00001	0.00255
1c,3-dimethylcyclohexane	0.01000	0.00014	0.52453	0.00008	0.00001	0.00229
nonene-1	0.02000	0.00025	0.18738	0.00005	0.00001	0.00164
1c,2t,4c-trimethylcyclohexane	0.02000	0.00025	0.16373	0.00004	0.00001	0.00143
3,4-dimethylheptane	0.02000	0.00025	0.11691	0.00003	0.000005	0.00102
1,1,2-trimethylcyclohexane	0.01000	0.00013	0.16373	0.00002	0.000003	0.00072
3,5-dimethylheptane	0.01000	0.00013	0.11691	0.00001	0.000002	0.00051

Sample 4, T=72.1° F

Average Molecular Weight		
Liquid Phase:	156.73	lb/lbmol
Vapor Phase:	53.04	lb/lbmol
Methane / Ethane		
Methane K:	167.10	
Methane Mass% Liq	0.00000000	%
Methane $y_i$	0.00	ppm
Methane Mass% Vap	0.00000000	%
Ethane K:	28.63	
Ethane $p_i$ :	0.58	psia

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
propane	0.70000	0.02488	128.84470	3.20556	0.54688	45.46606
n-butane	1.85000	0.04988	32.33790	1.61316	0.27521	30.15826
n-pentane	2.20000	0.04779	8.94467	0.42746	0.07293	9.91995
i-butane	0.36000	0.00971	46.68395	0.45317	0.07731	8.47213
i-pentane	1.11000	0.02411	12.06945	0.29102	0.04965	6.75356
ethane	0.06000	0.00313		0.57642	0.08953	5.07587
n-hexane	2.0000	0.03637	2.59458	0.09437	0.01610	2.61589
2-methylpentane	1.06000	0.01928	3.65310	0.07042	0.01201	1.95205
methylcyclopentane	1.0000	0.01862	2.35878	0.04393	0.00749	1.18908
3-methylpentane	0.72000	0.01309	3.27061	0.04283	0.00731	1.18709
n-heptane	1.82000	0.02847	0.77018	0.02192	0.00374	0.70662
cyclopentane	0.25000	0.00559	5.50431	0.03075	0.00525	0.69369
methylcyclohexane	1.33000	0.02123	0.78425	0.01665	0.00284	0.52581
cyclohexane	0.55000	0.01024	1.66588	0.01706	0.00291	0.46188
1t,2-dimethylcyclopentane	0.70000	0.01117	1.28929	0.01441	0.00246	0.45496
3-methylhexane	0.81000	0.01267	1.04376	0.01322	0.00226	0.42619
2-methylhexane	0.58000	0.00907	1.11769	0.01014	0.00173	0.32679
1t,3-dimethylcyclopentane	0.44000	0.00702	1.28929	0.00905	0.00154	0.28597
1c,3-dimethylcyclopentane	0.38000	0.00607	1.28929	0.00782	0.00133	0.24698
benzene	0.20000	0.00401	1.61828	0.00649	0.00111	0.16316
n-octane	1.29000	0.01770	0.23106	0.00409	0.00070	0.15026
2,3-dimethylpentane	0.23000	0.00360	1.17057	0.00421	0.00072	0.13572
2-methylheptane	0.73000	0.01002	0.34326	0.00344	0.00059	0.12632
1,1-dimethylcyclopentane	0.16000	0.00255	1.28929	0.00329	0.00056	0.10399
toluene	0.40000	0.00680	0.47674	0.00324	0.00055	0.09613
3-methylheptane	0.46000	0.00631	0.34326	0.00217	0.00037	0.07960
1c,2t,3-trimethylcyclopentane	0.58000	0.00810	0.26991	0.00219	0.00037	0.07892
2,2-dimethylhexane	0.27000	0.00370	0.57233	0.00212	0.00036	0.07790
2,2,3-trimethylhexane	0.64000	0.00782	0.18914	0.00148	0.00025	0.06102
2,2-dimethylbutane	0.02000	0.00036	5.54852	0.00202	0.00034	0.05594
4-methylheptane	0.27000	0.00370	0.34223	0.00127	0.00022	0.04658

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
1t,2c,3-trimethylcyclopentane	0.33000	0.00461	0.26991	0.00124	0.00021	0.04490
1c,2t,4-trimethylcyclopentane	0.32000	0.00447	0.26991	0.00121	0.00021	0.04354
1c,2c,3-trimethylcyclopentane	0.28000	0.00391	0.26991	0.00106	0.00018	0.03810
n-propylcyclopentane	0.27000	0.00377	0.26991	0.00102	0.00017	0.03674
2-methyl-3-ethylpentane	0.12000	0.00165	0.50948	0.00084	0.00014	0.03082
2,5-dimethylhexane	0.12000	0.00165	0.50948	0.00084	0.00014	0.03082
2,4-dimethylhexane	0.12000	0.00165	0.50803	0.00084	0.00014	0.03073
n-nonane	1.04000	0.01271	0.05669	0.00072	0.00012	0.02972
2,2,3-trimethylpentane	0.07000	0.00096	0.83572	0.00080	0.00014	0.02949
1t,4-dimethylcyclohexane	0.21000	0.00293	0.26991	0.00079	0.00014	0.02857
1,3-dimethylbenzene	0.37000	0.00546	0.13786	0.00075	0.00013	0.02571
i-propylcyclopentane	0.17000	0.00237	0.26991	0.00064	0.00011	0.02313
2t-ethylmethylcyclopentane	0.16000	0.00223	0.26991	0.00060	0.00010	0.02177
2,3-dimethylhexane	0.11000	0.00151	0.39143	0.00059	0.00010	0.02171
1,4-dimethylbenzene	0.27000	0.00399	0.14614	0.00058	0.00010	0.01989
2,2-dimethylpentane	0.02000	0.00031	1.79972	0.00056	0.00010	0.01814
2,4-dimethylpentane	0.02000	0.00031	1.68004	0.00053	0.00009	0.01694
3-ethylhexane	0.09000	0.00123	0.33317	0.00041	0.00007	0.01512
3,3-dimethylpentane	0.02000	0.00031	1.41421	0.00044	0.00008	0.01426
3-methyloctane	0.39000	0.00477	0.05669	0.00027	0.00005	0.01115
3,4-dimethylhexane	0.06000	0.00082	0.36235	0.00030	0.00005	0.01096
1c,2-dimethylcyclopentane	0.08000	0.00128	0.26991	0.00034	0.00006	0.01089
2,3,5-trimethylhexane	0.11000	0.00134	0.18914	0.00025	0.00004	0.01049
1,2-dimethylbenzene	0.18000	0.00266	0.10833	0.00029	0.00005	0.00983
3-methyl-3-ethylpentane	0.05000	0.00069	0.38632	0.00027	0.00005	0.00974
1c,2-dimethylcyclohexane	0.08000	0.00112	0.24055	0.00027	0.00005	0.00970
1,1-dimethylcyclohexane	0.07000	0.00098	0.26991	0.00026	0.00005	0.00952
3c-ethylmethylcyclopentane	0.07000	0.00098	0.26991	0.00026	0.00005	0.00952
3t-ethylmethylcyclopentane	0.06000	0.00084	0.26991	0.00023	0.00004	0.00816
ethylbenzene	0.10000	0.00148	0.15620	0.00023	0.00004	0.00787
2-methyloctane	0.26000	0.00318	0.05669	0.00018	0.00003	0.00743
3,3-dimethylhexane	0.03000	0.00041	0.47758	0.00020	0.00003	0.00722
4-methyloctane	0.24000	0.00293	0.05669	0.00017	0.00003	0.00686
2,4,4-trimethylhexane	0.05000	0.00061	0.22259	0.00014	0.00002	0.00561
3,3-dimethylheptene-1	0.12000	0.00149	0.08699	0.00013	0.00002	0.00526
2,6-dimethylheptane	0.04000	0.00049	0.18914	0.00009	0.00002	0.00381
2,5-dimethylheptane	0.12000	0.00147	0.05669	0.00008	0.00001	0.00343
2,4-dimethylheptane	0.03000	0.00037	0.18914	0.00007	0.00001	0.00286
1,1-methylethylcyclopentane	0.02000	0.00028	0.26991	0.00008	0.00001	0.00272
1c,3-dimethylcyclohexane	0.02000	0.00028	0.26991	0.00008	0.00001	0.00272
1,1,4-trimethylcyclohexane	0.06000	0.00074	0.07721	0.00006	0.00001	0.00234
3,3-diethylpentane	0.08000	0.00098	0.05669	0.00006	0.00001	0.00229
3,3-dimethylheptane	0.07000	0.00086	0.05669	0.00005	0.00001	0.00200
1,1,3-trimethylcyclohexane	0.05000	0.00062	0.07721	0.00005	0.00001	0.00195

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
2,3,4-trimethylhexane	0.02000	0.00024	0.18914	0.00005	0.00001	0.00191
4-ethylheptane	0.05000	0.00061	0.05669	0.00003	0.00001	0.00143
1c,2t,4c-trimethylcyclohexane	0.03000	0.00037	0.07721	0.00003	0.000005	0.00117
3,4-dimethylheptane	0.04000	0.00049	0.05669	0.00003	0.000005	0.00114
2,4-dimethylheptene-1	0.02000	0.00025	0.08699	0.00002	0.000004	0.00088
nonene-1	0.02000	0.00025	0.08699	0.00002	0.000004	0.00088
1,1,2-trimethylcyclohexane	0.01000	0.00012	0.07721	0.00001	0.000002	0.00039
1c,2t,3c-trimethylcyclohexane	0.01000	0.00012	0.07721	0.00001	0.000002	0.00039
3,5-dimethylheptane	0.01000	0.00012	0.05669	0.00001	0.000001	0.00029

Sample 4, T=95° F

Average Molecular Weight		
Liquid Phase:	156.73	lb/lbmol
Vapor Phase:	53.57	lb/lbmol
Methane / Ethane		
Methane K:	190.00	
Methane Mass% Liq	0.00000000	%
Methane $y_i$	0.00	ppm
Methane Mass% Vap	0.00000000	%
Ethane K:	35.50	
Ethane $p_i$ :	1.03	psia

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
propane	0.70000	0.02488	176.65380	4.39501	0.53058	43.67220
n-butane	1.85000	0.04988	47.45453	2.36724	0.28578	31.00513
n-pentane	2.20000	0.04779	14.16178	0.67678	0.08170	11.00335
i-butane	0.36000	0.00971	67.05331	0.65090	0.07858	8.52525
i-pentane	1.11000	0.02411	18.67352	0.45025	0.05436	7.32038
ethane	0.06000	0.00313		1.03445	0.11102	6.23121
n-hexane	2.0000	0.03637	4.43665	0.16138	0.01948	3.13379
2-methylpentane	1.06000	0.01928	6.08944	0.11739	0.01417	2.27965
methylcyclopentane	1.0000	0.01862	4.03151	0.07508	0.00906	1.42381
3-methylpentane	0.72000	0.01309	5.48122	0.07177	0.00866	1.39378
n-heptane	1.82000	0.02847	1.42681	0.04062	0.00490	0.91711
cyclopentane	0.25000	0.00559	8.96348	0.05008	0.00605	0.79141
methylcyclohexane	1.33000	0.02123	1.42286	0.03021	0.00365	0.66834
cyclohexane	0.55000	0.01024	2.90982	0.02980	0.00360	0.56521
1t,2-dimethylcyclopentane	0.70000	0.01117	2.27727	0.02544	0.00307	0.56299
3-methylhexane	0.81000	0.01267	1.88579	0.02389	0.00288	0.53946
2-methylhexane	0.58000	0.00907	2.01204	0.01825	0.00220	0.41214
1t,3-dimethylcyclopentane	0.44000	0.00702	2.27727	0.01599	0.00193	0.35388
1c,3-dimethylcyclopentane	0.38000	0.00607	2.27727	0.01381	0.00167	0.30562
n-octane	1.29000	0.01770	0.46549	0.00824	0.00099	0.21207
benzene	0.20000	0.00401	2.86487	0.01150	0.00139	0.20236
2-methylheptane	0.73000	0.01002	0.66923	0.00670	0.00081	0.17254
2,3-dimethylpentane	0.23000	0.00360	2.08700	0.00751	0.00091	0.16953
1,1-dimethylcyclopentane	0.16000	0.00255	2.27727	0.00582	0.00070	0.12868
toluene	0.40000	0.00680	0.90368	0.00615	0.00074	0.12766
3-methylheptane	0.46000	0.00631	0.66923	0.00422	0.00051	0.10872
1c,2t,3-trimethylcyclopentane	0.58000	0.00810	0.52453	0.00425	0.00051	0.10744
2,2-dimethylhexane	0.27000	0.00370	1.06869	0.00396	0.00048	0.10191
2,2,3-trimethylhexane	0.64000	0.00782	0.37895	0.00296	0.00036	0.08565
4-methylheptane	0.27000	0.00370	0.66709	0.00247	0.00030	0.06361
2,2-dimethylbutane	0.02000	0.00036	8.93253	0.00325	0.00039	0.06309

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
1t,2c,3-trimethylcyclopentane	0.33000	0.00461	0.52453	0.00242	0.00029	0.06113
1c,2t,4-trimethylcyclopentane	0.32000	0.00447	0.52453	0.00234	0.00028	0.05928
1c,2c,3-trimethylcyclopentane	0.28000	0.00391	0.52453	0.00205	0.00025	0.05187
n-propylcyclopentane	0.27000	0.00377	0.52453	0.00198	0.00024	0.05002
n-nonane	1.04000	0.01271	0.11691	0.00149	0.00018	0.04294
2-methyl-3-ethylpentane	0.12000	0.00165	0.96528	0.00159	0.00019	0.04091
2,5-dimethylhexane	0.12000	0.00165	0.96528	0.00159	0.00019	0.04091
2,4-dimethylhexane	0.12000	0.00165	0.96101	0.00158	0.00019	0.04073
1t,4-dimethylcyclohexane	0.21000	0.00293	0.52453	0.00154	0.00019	0.03890
2,2,3-trimethylpentane	0.07000	0.00096	1.51201	0.00145	0.00018	0.03738
1,3-dimethylbenzene	0.37000	0.00546	0.28049	0.00153	0.00018	0.03665
i-propylcyclopentane	0.17000	0.00237	0.52453	0.00125	0.00015	0.03149
2t-ethylmethylcyclopentane	0.16000	0.00223	0.52453	0.00117	0.00014	0.02964
2,3-dimethylhexane	0.11000	0.00151	0.75123	0.00113	0.00014	0.02918
1,4-dimethylbenzene	0.27000	0.00399	0.29779	0.00119	0.00014	0.02840
2,2-dimethylpentane	0.02000	0.00031	3.11782	0.00098	0.00012	0.02202
2,4-dimethylpentane	0.02000	0.00031	2.93417	0.00092	0.00011	0.02073
3-ethylhexane	0.09000	0.00123	0.65042	0.00080	0.00010	0.02067
3,3-dimethylpentane	0.02000	0.00031	2.47165	0.00077	0.00009	0.01746
3-methyloctane	0.39000	0.00477	0.11691	0.00056	0.00007	0.01610
1c,2-dimethylcyclopentane	0.08000	0.00128	0.52453	0.00067	0.00008	0.01482
3,4-dimethylhexane	0.06000	0.00082	0.69690	0.00057	0.00007	0.01477
2,3,5-trimethylhexane	0.11000	0.00134	0.37895	0.00051	0.00006	0.01472
1,2-dimethylbenzene	0.18000	0.00266	0.22572	0.00060	0.00007	0.01435
1c,2-dimethylcyclohexane	0.08000	0.00112	0.47036	0.00053	0.00006	0.01329
1,1-dimethylcyclohexane	0.07000	0.00098	0.52453	0.00051	0.00006	0.01297
3c-ethylmethylcyclopentane	0.07000	0.00098	0.52453	0.00051	0.00006	0.01297
3-methyl-3-ethylpentane	0.05000	0.00069	0.73113	0.00050	0.00006	0.01291
ethylbenzene	0.10000	0.00148	0.31926	0.00047	0.00006	0.01128
3t-ethylmethylcyclopentane	0.06000	0.00084	0.52453	0.00044	0.00005	0.01111
2-methyloctane	0.26000	0.00318	0.11691	0.00037	0.00004	0.01074
4-methyloctane	0.24000	0.00293	0.11691	0.00034	0.00004	0.00991
3,3-dimethylhexane	0.03000	0.00041	0.90338	0.00037	0.00004	0.00957
3,3-dimethylheptene-1	0.12000	0.00149	0.18738	0.00028	0.00003	0.00794
2,4,4-trimethylhexane	0.05000	0.00061	0.43934	0.00027	0.00003	0.00776
2,6-dimethylheptane	0.04000	0.00049	0.37895	0.00019	0.00002	0.00535
2,5-dimethylheptane	0.12000	0.00147	0.11691	0.00017	0.00002	0.00495
2,4-dimethylheptane	0.03000	0.00037	0.37895	0.00014	0.00002	0.00402
1,1-methylethylcyclopentane	0.02000	0.00028	0.52453	0.00015	0.00002	0.00370
1c,3-dimethylcyclohexane	0.02000	0.00028	0.52453	0.00015	0.00002	0.00370
1,1,4-trimethylcyclohexane	0.06000	0.00074	0.16373	0.00012	0.00001	0.00347
3,3-diethylpentane	0.08000	0.00098	0.11691	0.00011	0.00001	0.00330
1,1,3-trimethylcyclohexane	0.05000	0.00062	0.16373	0.00010	0.00001	0.00289
3,3-dimethylheptane	0.07000	0.00086	0.11691	0.00010	0.00001	0.00289

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
2,3,4-trimethylhexane	0.02000	0.00024	0.37895	0.00009	0.00001	0.00268
4-ethylheptane	0.05000	0.00061	0.11691	0.00007	0.00001	0.00206
1c,2t,4c-trimethylcyclohexane	0.03000	0.00037	0.16373	0.00006	0.00001	0.00173
3,4-dimethylheptane	0.04000	0.00049	0.11691	0.00006	0.00001	0.00165
2,4-dimethylheptene-1	0.02000	0.00025	0.18738	0.00005	0.00001	0.00132
nonene-1	0.02000	0.00025	0.18738	0.00005	0.00001	0.00132
1,1,2-trimethylcyclohexane	0.01000	0.00012	0.16373	0.00002	0.000002	0.00058
1c,2t,3c-trimethylcyclohexane	0.01000	0.00012	0.16373	0.00002	0.000002	0.00058
3,5-dimethylheptane	0.01000	0.00012	0.11691	0.00001	0.000002	0.00041

Sample 5, T=72.1° F

Average Molecular Weight		
Liquid Phase:	152.85	lb/lbmol
Vapor Phase:	55.94	lb/lbmol
Methane / Ethane		
Methane K:	167.10	
Methane Mass% Liq	0.00000000	%
Methane $y_i$	0.00	ppm
Methane Mass% Vap	0.00000000	%
Ethane K:	28.63	
Ethane $p_i$ :	0.26	psia

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
propane	0.44000	0.01525	128.84470	1.96514	0.45897	36.17973
n-butane	1.30000	0.03419	32.33790	1.10556	0.25821	26.82880
n-pentane	1.82000	0.03856	8.94467	0.34489	0.08055	10.38919
i-butane	0.30000	0.00789	46.68395	0.36831	0.08602	8.93789
i-pentane	1.13000	0.02394	12.06945	0.28894	0.06748	8.70386
ethane	0.04000	0.00203		0.26466	0.05821	3.12922
n-hexane	1.85000	0.03281	2.59458	0.08514	0.01988	3.06327
2-methylpentane	1.02000	0.01809	3.65310	0.06609	0.01544	2.37798
cyclohexane	1.62000	0.02942	1.66588	0.04901	0.01145	1.72229
methylcyclohexane	2.94000	0.04577	0.78425	0.03589	0.00838	1.47145
methylcyclopentane	0.94000	0.01707	2.35878	0.04027	0.00941	1.41501
3-methylpentane	0.63000	0.01117	3.27061	0.03655	0.00854	1.31497
n-heptane	1.90000	0.02898	0.77018	0.02232	0.00521	0.93388
cyclopentane	0.17000	0.00371	5.50431	0.02039	0.00476	0.59717
3-methylhexane	0.71000	0.01083	1.04376	0.01130	0.00264	0.47294
1t,2-dimethylcyclopentane	0.52000	0.00810	1.28929	0.01044	0.00244	0.42786
2-methylhexane	0.57000	0.00869	1.11769	0.00972	0.00227	0.40658
2,3-dimethylbutane	0.11000	0.00195	4.06734	0.00794	0.00185	0.28553
benzene	0.27000	0.00528	1.61828	0.00855	0.00200	0.27885
1c,3-dimethylcyclopentane	0.33000	0.00514	1.28929	0.00662	0.00155	0.27152
1t,3-dimethylcyclopentane	0.31000	0.00483	1.28929	0.00622	0.00145	0.25507
toluene	0.83000	0.01377	0.47674	0.00656	0.00153	0.25252
n-octane	1.53000	0.02047	0.23106	0.00473	0.00110	0.22562
1,1-dimethylcyclopentane	0.23000	0.00358	1.28929	0.00462	0.00108	0.18924
2-methylheptane	0.81000	0.01084	0.34326	0.00372	0.00087	0.17744
1c,2t,3-trimethylcyclopentane	0.88000	0.01199	0.26991	0.00324	0.00076	0.15158
2,3-dimethylpentane	0.18000	0.00275	1.17057	0.00321	0.00075	0.13447
2,2-dimethylbutane	0.03000	0.00053	5.54852	0.00295	0.00069	0.10623
2,2-dimethylhexane	0.27000	0.00361	0.57233	0.00207	0.00048	0.09862
3-methylheptane	0.41000	0.00549	0.34326	0.00188	0.00044	0.08982
2,4-dimethylpentane	0.07000	0.00107	1.68004	0.00179	0.00042	0.07505

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
n-propylcyclopentane	0.35000	0.00477	0.26991	0.00129	0.00030	0.06029
1t,2-dimethylcyclohexane	0.37000	0.00504	0.24055	0.00121	0.00028	0.05680
1t,4-dimethylcyclohexane	0.32000	0.00436	0.26991	0.00118	0.00027	0.05512
1,3-dimethylbenzene	0.61000	0.00878	0.13786	0.00121	0.00028	0.05367
4-methylheptane	0.23000	0.00308	0.34223	0.00105	0.00025	0.05023
n-nonane	1.31000	0.01561	0.05669	0.00089	0.00021	0.04740
ethylcyclopentane	0.11000	0.00171	0.67389	0.00115	0.00027	0.04731
2,3-dimethylhexane	0.18000	0.00241	0.39143	0.00094	0.00022	0.04496
i-propylcyclopentane	0.25000	0.00341	0.26991	0.00092	0.00021	0.04306
1c,2t,4-trimethylcyclopentane	0.24000	0.00327	0.26991	0.00088	0.00021	0.04134
1t,2c,3-trimethylcyclopentane	0.22000	0.00300	0.26991	0.00081	0.00019	0.03790
3-ethylpentane	0.06000	0.00092	0.98304	0.00090	0.00021	0.03764
2,2,3-trimethylhexane	0.29000	0.00346	0.18914	0.00065	0.00015	0.03500
1,1,4-trimethylcyclohexane	0.70000	0.00848	0.07721	0.00065	0.00015	0.03449
2,2-dimethylpentane	0.03000	0.00046	1.79972	0.00082	0.00019	0.03446
2,4-dimethylhexane	0.10000	0.00134	0.50803	0.00068	0.00016	0.03242
1,4-dimethylbenzene	0.33000	0.00475	0.14614	0.00069	0.00016	0.03078
2,5-dimethylhexane	0.08000	0.00107	0.50948	0.00055	0.00013	0.02601
1,1-dimethylcyclohexane	0.13000	0.00177	0.26991	0.00048	0.00011	0.02239
3,3-dimethylpentane	0.02000	0.00031	1.41421	0.00043	0.00010	0.01805
2t-ethylmethylcyclopentane	0.10000	0.00136	0.26991	0.00037	0.00009	0.01723
1,2-dimethylbenzene	0.22000	0.00317	0.10833	0.00034	0.00008	0.01521
ethylbenzene	0.15000	0.00216	0.15620	0.00034	0.00008	0.01495
3-ethylhexane	0.07000	0.00094	0.33317	0.00031	0.00007	0.01488
1c,2-dimethylcyclopentane	0.08000	0.00125	0.26991	0.00034	0.00008	0.01378
3-methyloctane	0.35000	0.00417	0.05669	0.00024	0.00006	0.01266
3,3-dimethylhexane	0.04000	0.00054	0.47758	0.00026	0.00006	0.01219
2,2,3-trimethylbutane	0.01000	0.00015	1.75367	0.00027	0.00006	0.01119
2-methyl-3-ethylpentane	0.03000	0.00040	0.50948	0.00020	0.00005	0.00975
3,4-dimethylhexane	0.04000	0.00054	0.36235	0.00019	0.00005	0.00925
2-methyloctane	0.25000	0.00298	0.05669	0.00017	0.00004	0.00904
3c-ethylmethylcyclopentane	0.05000	0.00068	0.26991	0.00018	0.00004	0.00861
3t-ethylmethylcyclopentane	0.05000	0.00068	0.26991	0.00018	0.00004	0.00861
4-methyloctane	0.21000	0.00250	0.05669	0.00014	0.00003	0.00760
3-methyl-3-ethylpentane	0.03000	0.00040	0.38632	0.00016	0.00004	0.00740
1,1-methylethylcyclopentane	0.03000	0.00041	0.26991	0.00011	0.00003	0.00517
2,6-dimethylheptane	0.04000	0.00048	0.18914	0.00009	0.00002	0.00483
2,5-dimethylheptane	0.13000	0.00155	0.05669	0.00009	0.00002	0.00470
1c,2-dimethylcyclohexane	0.03000	0.00041	0.24055	0.00010	0.00002	0.00461
2,4,4-trimethylhexane	0.03000	0.00036	0.22259	0.00008	0.00002	0.00426
*1c,3c,5-trimethylcyclohexane	0.07000	0.00085	0.07721	0.00007	0.00002	0.00345
1c,3-dimethylcyclohexane	0.02000	0.00027	0.26991	0.00007	0.00002	0.00345
4-ethylheptane	0.08000	0.00095	0.05669	0.00005	0.00001	0.00289
2,3,4-trimethylpentane	0.01000	0.00013	0.44990	0.00006	0.00001	0.00287

Component	$m_{\text{liq}}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{\text{vap}}$ (%)
2,2,3,4-tetramethylpentane	0.02000	0.00024	0.20988	0.00005	0.00001	0.00268
2,3,4-trimethylhexane	0.02000	0.00024	0.18914	0.00005	0.00001	0.00241
2,4-dimethylheptane	0.02000	0.00024	0.18914	0.00005	0.00001	0.00241
3,3-diethylpentane	0.06000	0.00072	0.05669	0.00004	0.00001	0.00217
c-octene-2	0.01000	0.00014	0.28862	0.00004	0.00001	0.00184
2,4-dimethylheptene-1	0.03000	0.00036	0.08699	0.00003	0.00001	0.00167
1c,2t,4c-trimethylcyclohexane	0.03000	0.00036	0.07721	0.00003	0.00001	0.00148
2,3,5-trimethylhexane	0.01000	0.00012	0.18914	0.00002	0.00001	0.00121
3,5-dimethylheptane	0.03000	0.00036	0.05669	0.00002	0.000005	0.00109
1,1,3-trimethylcyclohexane	0.02000	0.00024	0.07721	0.00002	0.000004	0.00099
i-butylcyclopentane	0.02000	0.00024	0.07721	0.00002	0.000004	0.00099
3,3-dimethylheptane	0.02000	0.00024	0.05669	0.00001	0.000003	0.00072
3,4-dimethylheptane	0.02000	0.00024	0.05669	0.00001	0.000003	0.00072
1c,2t,3c-trimethylcyclohexane	0.01000	0.00012	0.07721	0.00001	0.000002	0.00049
2,2-dimethylheptane	0.01000	0.00012	0.05669	0.00001	0.000002	0.00036

Sample 5, T=95° F

Average Molecular Weight		
Liquid Phase:	152.85	lb/lbmol
Vapor Phase:	56.79	lb/lbmol
Methane / Ethane		
Methane K:	190.00	
Methane Mass% Liq	0.00000000	%
Methane $y_i$	0.00	ppm
Methane Mass% Vap	0.00000000	%
Ethane K:	35.50	
Ethane $p_i$ :	0.48	psia

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^o$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
propane	0.44000	0.01525	176.65380	2.69433	0.43569	33.83301
n-butane	1.30000	0.03419	47.45453	1.62237	0.26235	26.85258
n-pentane	1.82000	0.03856	14.16178	0.54605	0.08830	11.21901
i-pentane	1.13000	0.02394	18.67352	0.44704	0.07229	9.18480
i-butane	0.30000	0.00789	67.05331	0.52902	0.08555	8.75602
ethane	0.04000	0.00203		0.48112	0.07218	3.82230
n-hexane	1.85000	0.03281	4.43665	0.14558	0.02354	3.57266
2-methylpentane	1.02000	0.01809	6.08944	0.11017	0.01782	2.70360
cyclohexane	1.62000	0.02942	2.90982	0.08561	0.01384	2.05185
methylcyclohexane	2.94000	0.04577	1.42286	0.06512	0.01053	1.82085
methylcyclopentane	0.94000	0.01707	4.03151	0.06883	0.01113	1.64953
3-methylpentane	0.63000	0.01117	5.48122	0.06125	0.00990	1.50308
n-heptane	1.90000	0.02898	1.42681	0.04135	0.00669	1.18000
cyclopentane	0.17000	0.00371	8.96348	0.03321	0.00537	0.66327
3-methylhexane	0.71000	0.01083	1.88579	0.02042	0.00330	0.58280
1t,2-dimethylcyclopentane	0.52000	0.00810	2.27727	0.01843	0.00298	0.51545
2-methylhexane	0.57000	0.00869	2.01204	0.01749	0.00283	0.49920
benzene	0.27000	0.00528	2.86487	0.01514	0.00245	0.33669
1c,3-dimethylcyclopentane	0.33000	0.00514	2.27727	0.01170	0.00189	0.32711
toluene	0.83000	0.01377	0.90368	0.01244	0.00201	0.32648
2,3-dimethylbutane	0.11000	0.00195	6.69218	0.01306	0.00211	0.32042
n-octane	1.53000	0.02047	0.46549	0.00953	0.00154	0.31000
1t,3-dimethylcyclopentane	0.31000	0.00483	2.27727	0.01099	0.00178	0.30729
2-methylheptane	0.81000	0.01084	0.66923	0.00725	0.00117	0.23595
1,1-dimethylcyclopentane	0.23000	0.00358	2.27727	0.00815	0.00132	0.22799
1c,2t,3-trimethylcyclopentane	0.88000	0.01199	0.52453	0.00629	0.00102	0.20092
2,3-dimethylpentane	0.18000	0.00275	2.08700	0.00573	0.00093	0.16352
2,2-dimethylhexane	0.27000	0.00361	1.06869	0.00386	0.00062	0.12560
3-methylheptane	0.41000	0.00549	0.66923	0.00367	0.00059	0.11943
2,2-dimethylbutane	0.03000	0.00053	8.93253	0.00475	0.00077	0.11664
2,4-dimethylpentane	0.07000	0.00107	2.93417	0.00313	0.00051	0.08940

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
n-propylcyclopentane	0.35000	0.00477	0.52453	0.00250	0.00040	0.07991
1t,2-dimethylcyclohexane	0.37000	0.00504	0.47036	0.00237	0.00038	0.07575
1,3-dimethylbenzene	0.61000	0.00878	0.28049	0.00246	0.00040	0.07448
1t,4-dimethylcyclohexane	0.32000	0.00436	0.52453	0.00229	0.00037	0.07306
4-methylheptane	0.23000	0.00308	0.66709	0.00205	0.00033	0.06678
n-nonane	1.31000	0.01561	0.11691	0.00183	0.00030	0.06666
ethylcyclopentane	0.11000	0.00171	1.24259	0.00213	0.00034	0.05950
2,3-dimethylhexane	0.18000	0.00241	0.75123	0.00181	0.00029	0.05886
i-propylcyclopentane	0.25000	0.00341	0.52453	0.00179	0.00029	0.05708
1c,2t,4-trimethylcyclopentane	0.24000	0.00327	0.52453	0.00171	0.00028	0.05480
1t,2c,3-trimethylcyclopentane	0.22000	0.00300	0.52453	0.00157	0.00025	0.05023
1,1,4-trimethylcyclohexane	0.70000	0.00848	0.16373	0.00139	0.00022	0.04989
2,2,3-trimethylhexane	0.29000	0.00346	0.37895	0.00131	0.00021	0.04784
3-ethylpentane	0.06000	0.00092	1.78043	0.00163	0.00026	0.04650
1,4-dimethylbenzene	0.33000	0.00475	0.29779	0.00141	0.00023	0.04277
2,4-dimethylhexane	0.10000	0.00134	0.96101	0.00129	0.00021	0.04183
2,2-dimethylpentane	0.03000	0.00046	3.11782	0.00143	0.00023	0.04071
2,5-dimethylhexane	0.08000	0.00107	0.96528	0.00103	0.00017	0.03361
1,1-dimethylcyclohexane	0.13000	0.00177	0.52453	0.00093	0.00015	0.02968
2t-ethylmethylcyclopentane	0.10000	0.00136	0.52453	0.00071	0.00012	0.02283
1,2-dimethylbenzene	0.22000	0.00317	0.22572	0.00071	0.00012	0.02161
3,3-dimethylpentane	0.02000	0.00031	2.47165	0.00075	0.00012	0.02152
ethylbenzene	0.15000	0.00216	0.31926	0.00069	0.00011	0.02084
3-ethylhexane	0.07000	0.00094	0.65042	0.00061	0.00010	0.01982
1c,2-dimethylcyclopentane	0.08000	0.00125	0.52453	0.00065	0.00011	0.01827
3-methyloctane	0.35000	0.00417	0.11691	0.00049	0.00008	0.01781
3,3-dimethylhexane	0.04000	0.00054	0.90338	0.00048	0.00008	0.01573
2,2,3-trimethylbutane	0.01000	0.00015	3.01654	0.00046	0.00007	0.01313
2-methyloctane	0.25000	0.00298	0.11691	0.00035	0.00006	0.01272
2-methyl-3-ethylpentane	0.03000	0.00040	0.96528	0.00039	0.00006	0.01260
3,4-dimethylhexane	0.04000	0.00054	0.69690	0.00037	0.00006	0.01213
3c-ethylmethylcyclopentane	0.05000	0.00068	0.52453	0.00036	0.00006	0.01142
3t-ethylmethylcyclopentane	0.05000	0.00068	0.52453	0.00036	0.00006	0.01142
4-methyloctane	0.21000	0.00250	0.11691	0.00029	0.00005	0.01069
3-methyl-3-ethylpentane	0.03000	0.00040	0.73113	0.00029	0.00005	0.00955
1,1-methylethylcyclopentane	0.03000	0.00041	0.52453	0.00021	0.00003	0.00685
2,5-dimethylheptane	0.13000	0.00155	0.11691	0.00018	0.00003	0.00662
2,6-dimethylheptane	0.04000	0.00048	0.37895	0.00018	0.00003	0.00660
1c,2-dimethylcyclohexane	0.03000	0.00041	0.47036	0.00019	0.00003	0.00614
2,4,4-trimethylhexane	0.03000	0.00036	0.43934	0.00016	0.00003	0.00574
*1c,3c,5-trimethylcyclohexane	0.07000	0.00085	0.16373	0.00014	0.00002	0.00499
1c,3-dimethylcyclohexane	0.02000	0.00027	0.52453	0.00014	0.00002	0.00457
4-ethylheptane	0.08000	0.00095	0.11691	0.00011	0.00002	0.00407
2,3,4-trimethylpentane	0.01000	0.00013	0.84444	0.00011	0.00002	0.00368

Component	$m_{liq}$ (%)	$\chi_i$	$p_i^\circ$ (psia)	$p_i$ (psia)	$y_i$	$m_{vap}$ (%)
2,2,3,4-tetramethylpentane	0.02000	0.00024	0.41398	0.00010	0.00002	0.00360
2,3,4-trimethylhexane	0.02000	0.00024	0.37895	0.00009	0.00001	0.00330
2,4-dimethylheptane	0.02000	0.00024	0.37895	0.00009	0.00001	0.00330
3,3-diethylpentane	0.06000	0.00072	0.11691	0.00008	0.00001	0.00305
c-octene-2	0.01000	0.00014	0.57018	0.00008	0.00001	0.00248
2,4-dimethylheptene-1	0.03000	0.00036	0.18738	0.00007	0.00001	0.00245
1c,2t,4c-trimethylcyclohexane	0.03000	0.00036	0.16373	0.00006	0.00001	0.00214
2,3,5-trimethylhexane	0.01000	0.00012	0.37895	0.00005	0.00001	0.00165
3,5-dimethylheptane	0.03000	0.00036	0.11691	0.00004	0.00001	0.00153
1,1,3-trimethylcyclohexane	0.02000	0.00024	0.16373	0.00004	0.00001	0.00143
i-butylcyclopentane	0.02000	0.00024	0.16373	0.00004	0.00001	0.00143
3,3-dimethylheptane	0.02000	0.00024	0.11691	0.00003	0.000005	0.00102
3,4-dimethylheptane	0.02000	0.00024	0.11691	0.00003	0.000005	0.00102
1c,2t,3c-trimethylcyclohexane	0.01000	0.00012	0.16373	0.00002	0.000003	0.00071
2,2-dimethylheptane	0.01000	0.00012	0.11691	0.00001	0.000002	0.00051

## Appendix A-4— Antoine Coefficients and Molecular Weights

$$\log_{10}(P/\text{bar}) = A - \frac{B}{T/\text{K} + C} \quad (9)$$

Compound	Formula	Mol. Wt.	VPsurrogate	A	B	C
*1c,3c,5-trimethylcyclohexane	C <sub>9</sub> H <sub>18</sub>	126.242	i-propylcyclohexane	—	—	—
1-nonene	—	—	—	4.079	1,435.359	-67.615
1-octene	—	—	—	4.058	1,353.486	-60.386
1,1-dimethylcyclohexane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
1,1-dimethylcyclopentane	C <sub>7</sub> H <sub>14</sub>	98.188	—	3.955	1,226.557	-50.393
1,1-methylethylcyclopentane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
1,1,2-trimethylcyclohexane	C <sub>9</sub> H <sub>18</sub>	126.242	i-propylcyclohexane	—	—	—
1,1,3-trimethylcyclohexane	C <sub>9</sub> H <sub>18</sub>	126.242	i-propylcyclohexane	—	—	—
1,1,4-trimethylcyclohexane	C <sub>9</sub> H <sub>18</sub>	126.242	i-propylcyclohexane	—	—	—
1,2-dimethylbenzene	C <sub>8</sub> H <sub>10</sub>	106.167	—	4.938	1,901.373	-26.268
1,3-dimethylbenzene	C <sub>8</sub> H <sub>10</sub>	106.167	—	5.092	1,996.545	-14.772
1,4-dimethylbenzene	C <sub>8</sub> H <sub>10</sub>	106.167	—	4.146	1,474.403	-55.377
1c,2-dimethylcyclohexane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	3.967	1,369.525	-57.110
1c,2-dimethylcyclopentane	C <sub>7</sub> H <sub>14</sub>	98.188	i-propylcyclopentane	—	—	—
1c,2c,3-trimethylcyclopentane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
1c,2t,3-trimethylcyclopentane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
1c,2t,3c-trimethylcyclohexane	C <sub>9</sub> H <sub>18</sub>	126.242	i-propylcyclohexane	—	—	—
1c,2t,4-trimethylcyclopentane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
1c,2t,4c-trimethylcyclohexane	C <sub>9</sub> H <sub>18</sub>	126.242	i-propylcyclohexane	—	—	—
1c,2t,4t-trimethylcyclohexane	C <sub>9</sub> H <sub>18</sub>	126.242	i-propylcyclohexane	—	—	—
1c,3-dimethylcyclohexane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
1c,3-dimethylcyclopentane	C <sub>7</sub> H <sub>14</sub>	98.188	1,1-dimethylcyclopentane	—	—	—
1c,3c,5c-trimethylcyclohexane	C <sub>9</sub> H <sub>18</sub>	126.242	—	—	—	—
1t,2-dimethylcyclohexane	C <sub>8</sub> H <sub>16</sub>	112.215	1c,2-dimethylcyclohexane	—	—	—
1t,2-dimethylcyclopentane	C <sub>7</sub> H <sub>14</sub>	98.188	1,1-dimethylcyclopentane	—	—	—
1t,2c,3-trimethylcyclopentane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
1t,3-dimethylcyclopentane	C <sub>7</sub> H <sub>14</sub>	98.188	1,1-dimethylcyclopentane	—	—	—
1t,4-dimethylcyclohexane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
2-methyl-3-ethylpentane	C <sub>8</sub> H <sub>18</sub>	114.231	2,5-dimethylhexane	—	—	—
2-methylheptane	C <sub>8</sub> H <sub>18</sub>	114.231	—	4.042	1,337.468	-59.457
2-methylhexane	C <sub>7</sub> H <sub>16</sub>	100.204	—	4.007	1,240.869	-53.047
2-methyloctane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
2-methylpentane	C <sub>6</sub> H <sub>14</sub>	86.177	—	3.964	1,135.410	-46.578
2,2-dimethylbutane	C <sub>6</sub> H <sub>14</sub>	86.177	—	3.880	1,081.176	-43.807
2,2-dimethylheptane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
2,2-dimethylhexane	C <sub>8</sub> H <sub>18</sub>	114.231	—	4.133	1,367.457	-48.436
2,2-dimethylpentane	C <sub>7</sub> H <sub>16</sub>	100.204	—	3.940	1,190.298	-49.807
2,2-dimethylpropane	C <sub>5</sub> H <sub>12</sub>	72.150	—	3.864	950.318	-36.329
2,2,3-trimethylbutane	C <sub>7</sub> H <sub>16</sub>	100.204	—	3.922	1,203.362	-46.776

Compound	Formula	Mol. Wt.	VPsurrogate	A	B	C
2,2,3-trimethylhexane	C <sub>9</sub> H <sub>20</sub>	128.258	—	4.414	1,592.354	-42.627
2,2,3-trimethylpentane	C <sub>8</sub> H <sub>18</sub>	114.231	2,2,4-trimethylpentane	—	—	—
2,2,3,4-tetramethylpentane	C <sub>9</sub> H <sub>20</sub>	128.258	—	3.960	1,376.496	-58.063
2,2,4-trimethylpentane	—	—	—	3.937	1,257.840	-52.415
2,2,5-trimethylhexane	C <sub>9</sub> H <sub>20</sub>	128.258	—	4.252	1,471.761	-48.948
2,3-dimethylbutane	C <sub>6</sub> H <sub>14</sub>	86.177	—	3.935	1,127.187	-44.200
2,3-dimethylhexane	C <sub>8</sub> H <sub>18</sub>	114.231	—	4.059	1,351.645	-55.257
2,3-dimethylpentane	C <sub>7</sub> H <sub>16</sub>	100.204	—	3.987	1,242.609	-50.806
2,3,4-trimethylhexane	C <sub>9</sub> H <sub>20</sub>	128.258	2,2,3-trimethylhexane	—	—	—
2,3,4-trimethylpentane	C <sub>8</sub> H <sub>18</sub>	114.231	—	4.156	1,420.710	-44.618
2,3,5-trimethylhexane	C <sub>9</sub> H <sub>20</sub>	128.258	2,2,3-trimethylhexane	—	—	—
2,4-dimethylheptane	C <sub>9</sub> H <sub>20</sub>	128.258	2,2,3-trimethylhexane	—	—	—
2,4-dimethylheptene-1	C <sub>9</sub> H <sub>18</sub>	126.242	1-nonene	—	—	—
2,4-dimethylhexane	C <sub>8</sub> H <sub>18</sub>	114.231	—	3.989	1,292.707	-57.970
2,4-dimethylpentane	C <sub>7</sub> H <sub>16</sub>	100.204	—	3.961	1,197.608	-50.877
2,4,4-trimethylhexane	C <sub>9</sub> H <sub>20</sub>	128.258	—	3.991	1,378.043	-58.046
2,5-dimethylheptane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
2,5-dimethylhexane	C <sub>8</sub> H <sub>18</sub>	114.231	—	3.980	1,284.664	-59.032
2,6-dimethylheptane	C <sub>9</sub> H <sub>20</sub>	128.258	2,2,3-trimethylhexane	—	—	—
2t-ethylmethylcyclopentane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
3-ethylheptane	C <sub>9</sub> H <sub>20</sub>	128.258	—	—	—	—
3-ethylhexane	C <sub>8</sub> H <sub>18</sub>	114.231	—	4.040	1,339.865	-59.479
3-ethylpentane	C <sub>7</sub> H <sub>16</sub>	100.204	—	4.005	1,254.119	-53.004
3-methyl-3-ethylpentane	C <sub>8</sub> H <sub>18</sub>	114.231	—	4.048	1,380.130	-49.963
3-methylheptane	C <sub>8</sub> H <sub>18</sub>	114.231	2-methylheptane	—	—	—
3-methylhexane	C <sub>7</sub> H <sub>16</sub>	100.204	—	3.999	1,243.759	-53.524
3-methyloctane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
3-methylpentane	C <sub>6</sub> H <sub>14</sub>	86.177	—	3.974	1,152.368	-46.021
3,3-diethylpentane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
3,3-dimethylheptane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
3,3-dimethylheptene-1	C <sub>9</sub> H <sub>18</sub>	126.242	1-nonene	—	—	—
3,3-dimethylhexane	C <sub>8</sub> H <sub>18</sub>	114.231	—	3.859	1,243.387	-62.655
3,3-dimethylpentane	C <sub>7</sub> H <sub>16</sub>	100.204	—	3.956	1,230.986	-47.568
3,4-dimethylheptane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
3,4-dimethylhexane	C <sub>8</sub> H <sub>18</sub>	114.231	—	4.098	1,382.877	-52.831
3,5-dimethylheptane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
3c-ethylmethylcyclopentane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
3t-ethylmethylcyclopentane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
4-ethylheptane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
4-methylheptane	C <sub>8</sub> H <sub>18</sub>	114.231	—	4.060	1,347.236	-58.539
4-methyloctane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
4,4-dimethylheptane	C <sub>9</sub> H <sub>20</sub>	128.258	n-nonane	—	—	—
benzene	C <sub>6</sub> H <sub>6</sub>	78.114	—	4.018	1,203.835	-53.226
c-nonene-3	C <sub>9</sub> H <sub>18</sub>	126.242	1-nonene	—	—	—

Compound	Formula	Mol. Wt.	VPsurrogate	A	B	C
c-octene-2	C <sub>8</sub> H <sub>16</sub>	112.215	1-octene	—	—	—
cyclohexane	C <sub>6</sub> H <sub>12</sub>	84.161	—	3.970	1,203.526	-50.287
cyclopentane	C <sub>5</sub> H <sub>10</sub>	70.134	—	4.003	1,119.208	-42.412
ethane	C <sub>2</sub> H <sub>6</sub>	30.070	—	—	—	—
ethylbenzene	C <sub>8</sub> H <sub>10</sub>	106.167	—	4.075	1,419.315	-60.539
ethylcyclopentane	C <sub>7</sub> H <sub>14</sub>	98.188	—	4.023	1,305.001	-51.755
i-butane	C <sub>4</sub> H <sub>10</sub>	58.123	—	4.328	1,132.108	0.918
i-butylcyclopentane	C <sub>9</sub> H <sub>18</sub>	126.242	i-propylcyclohexane	—	—	—
i-pentane	C <sub>5</sub> H <sub>12</sub>	72.150	—	3.915	1,020.012	-40.053
i-propylcyclohexane	—	—	—	3.997	1,452.816	-63.759
i-propylcyclopentane	C <sub>8</sub> H <sub>16</sub>	112.215	—	4.017	1,383.340	-54.742
methylcyclohexane	C <sub>7</sub> H <sub>14</sub>	98.188	1,1-dimethylcyclopentane	3.952	1,272.865	-51.520
methylcyclopentane	C <sub>6</sub> H <sub>12</sub>	84.161	—	3.988	1,186.059	-47.108
n-butane	C <sub>4</sub> H <sub>10</sub>	58.123	—	4.356	1,175.581	-2.071
n-heptane	C <sub>7</sub> H <sub>16</sub>	100.204	—	4.028	1,268.636	-56.199
n-hexane	C <sub>6</sub> H <sub>14</sub>	86.177	—	4.003	1,171.530	-48.784
n-nonane	C <sub>9</sub> H <sub>20</sub>	128.258	—	3.825	1,492.928	-55.895
n-octane	C <sub>8</sub> H <sub>18</sub>	114.231	—	4.049	1,355.126	-63.633
n-pentane	C <sub>5</sub> H <sub>12</sub>	72.150	—	3.989	1,070.617	-40.454
n-propylcyclopentane	C <sub>8</sub> H <sub>16</sub>	112.215	i-propylcyclopentane	—	—	—
nonene-1	C <sub>9</sub> H <sub>18</sub>	126.242	—	4.079	1,435.359	-67.615
propane	C <sub>3</sub> H <sub>8</sub>	44.097	—	4.537	1,149.360	24.906
Styrene	C <sub>8</sub> H <sub>8</sub>	104.152	—	4.059	1,459.909	-59.551
t-7-methyloctene-3	C <sub>9</sub> H <sub>18</sub>	126.242	1-nonene	—	—	—
toluene	C <sub>7</sub> H <sub>8</sub>	92.141	—	4.142	1,377.578	-50.507

## Appendix B-1— Constituent CAS Numbers, ESL's, and ESL Surrogates

∞ = "Simple asphyxiant"

Component	CAS	1-hr ESL (µg/m <sup>3</sup> )	Ann. ESL (µg/m <sup>3</sup> )	Surrogate
ethylbenzene	100-41-4	26,000	570	—
Styrene	100-42-5	110	140	—
1,4-dimethylbenzene	106-42-3	2,200	180	xylene
n-butane	106-97-8	66,000	7,100	—
3-methyl-3-ethylpentane	1067-08-9	5,600	540	n-octane
3,3-diethylpentane	1067-20-5	4,800	450	n-nonane
4,4-dimethylheptane	1068-19-5	4,800	450	n-nonane
2,3,5-trimethylhexane	1069-53-0	4,800	450	n-nonane
2-methylpentane	107-83-5	5,600	200	n-hexane
2,2,3,4-tetramethylpentane	1070-87-7	4,800	450	n-nonane
2,2-dimethylheptane	1071-26-7	4,800	450	n-nonane
2,4-dimethylheptane	1071-26-7	4,800	450	n-nonane
2,4-dimethylpentane	108-08-7	10,000	2,700	n-heptane
1,3-dimethylbenzene	108-38-3	2,200	180	xylene
methylcyclohexane	108-87-2	16,100	1,610	—
toluene	108-88-3	4,500	1,200	—
n-pentane	109-66-0	59,000	7,100	—
n-hexane	110-54-3	5,600	200	—
cyclohexane	110-82-7	3,400	340	—
n-octane	111-65-9	5,600	540	—
n-nonane	111-84-2	4,800	450	—
nonene-1	124-11-8	5,700	570	alkenes, generic, not otherwise specified
n-heptane	142-82-5	10,000	2,700	—
ethylcyclopentane	1640-89-7	16,300	1,630	—
2,2,3-trimethylhexane	16747-25-4	4,800	450	n-nonane
1t,3-dimethylcyclopentane	1759-58-6	3,500	350	—
*1c,3c,5-trimethylcyclohexane	1839-63-0	3,400	340	cyclohexane
1c,2t,4t-trimethylcyclohexane	1839-63-0	3,400	340	cyclohexane
1c,2t,4c-trimethylcyclohexane	1839-63-0	3,400	340	cyclohexane
1,1,4-trimethylcyclohexane	1839-63-0	3,400	340	cyclohexane
1c,2t,3c-trimethylcyclohexane	1839-63-0	3,400	340	cyclohexane
1,1,3-trimethylcyclohexane	1839-63-0	3,400	340	cyclohexane
3,3-dimethylheptene-1	19549-87-2	5,700	570	alkenes, generic, not otherwise specified
2,4-dimethylheptene-1	19549-87-2	5,700	570	alkenes, generic, not otherwise specified
i-butylcyclopentane	2040-95-1	3,500	350	—

Component	CAS	1-hr ESL ( $\mu\text{g}/\text{m}^3$ )	Ann. ESL ( $\mu\text{g}/\text{m}^3$ )	Surrogate
n-propylcyclopentane	2040-96-2	3,500	350	—
i-propylcyclopentane	2040-96-2	3,500	350	—
1c,2-dimethylcyclohexane	2207-01-4	3,400	340	cyclohexane
2,5-dimethylheptane	2216-30-0	4,800	450	n-nonane
2,6-dimethylheptane	2216-30-0	4,800	450	n-nonane
4-ethylheptane	2216-32-2	4,800	450	n-nonane
3-methyloctane	2216-33-3	4,800	450	n-nonane
4-methyloctane	2216-34-4	4,800	450	n-nonane
1c,3-dimethylcyclopentane	2532-58-3	3,500	350	—
c-octene-2	25377-83-7	3,400	340	1-octene
3t-ethylmethylcyclopentane	2613-65-2	3,500	350	—
cyclopentane	287-92-3	17,000	1,700	—
2-methyloctane	3221-61-2	4,800	450	n-nonane
2,2,5-trimethylhexane	3522-94-9	4,800	450	n-nonane
1,1-methylethylcyclopentane	3875-51-2	3,500	350	—
3c-ethylmethylcyclopentane	3875-51-2	3,500	350	—
3,3-dimethylheptane	4032-86-4	4,800	450	n-nonane
2,2-dimethylpropane	463-82-1	59,000	7,100	n-pentane
2,2,3-trimethylbutane	464-06-2	10,000	2,700	n-heptane
1c,2t,3-trimethylcyclopentane	4850-28-6	3,500	350	dimethylcyclopentane, all isomers
1,1-dimethylcyclopentane	4850-28-6	3,500	350	dimethylcyclopentane, all isomers
1c,2t,4-trimethylcyclopentane	4850-28-6	3,500	350	dimethylcyclopentane, all isomers
1t,2c,3-trimethylcyclopentane	4850-28-6	3,500	350	dimethylcyclopentane, all isomers
1c,2c,3-trimethylcyclopentane	4850-28-6	3,500	350	dimethylcyclopentane, all isomers
1c,2-dimethylcyclopentane	4850-28-6	3,500	350	dimethylcyclopentane, all isomers
3,3-dimethylpentane	562-49-2	10,000	2,700	n-heptane
3,3-dimethylhexane	563-16-6	5,600	540	n-octane
2,2,3-trimethylpentane	564-02-3	5,600	540	n-octane
2,3,4-trimethylpentane	564-02-3	5,600	540	n-octane
2,3-dimethylpentane	565-59-3	10,000	2,700	n-heptane
3,4-dimethylhexane	583-48-2	5,600	540	n-octane
2,3-dimethylhexane	584-94-1	5,600	540	n-octane
3-methylhexane	589-34-4	10,000	2,700	n-heptane
2,4-dimethylhexane	589-43-5	5,600	540	n-octane
4-methylheptane	589-53-7	5,600	540	n-octane
3-methylheptane	589-81-1	5,600	540	n-octane
2,2-dimethylpentane	590-35-2	10,000	2,700	n-heptane
1,1-dimethylcyclohexane	590-66-9	16,100	1,610	methylcyclohexane

Component	CAS	1-hr ESL ( $\mu\text{g}/\text{m}^3$ )	Ann. ESL ( $\mu\text{g}/\text{m}^3$ )	Surrogate
2,2-dimethylhexane	590-73-8	5,600	540	n-octane
2-methylhexane	591-76-4	10,000	2,700	n-heptane
2,5-dimethylhexane	592-13-2	5,600	540	n-octane
2-methylheptane	592-27-8	5,600	540	n-octane
2-methyl-3-ethylpentane	609-26-7	5,600	540	n-octane
3-ethylpentane	617-78-7	10,000	2,700	n-heptane
3-ethylhexane	619-99-8	5,600	540	n-octane
1t,4-dimethylcyclohexane	624-29-3	16,100	1,610	methylcyclohexane
1t,2-dimethylcyclohexane	624-29-3	16,100	1,610	methylcyclohexane
1c,3-dimethylcyclohexane	638-04-0	16,100	1,610	methylcyclohexane
1,1,2-trimethylcyclohexane	7094-26-0	3,400	340	cyclohexane
benzene	71-43-2	170	4,500	—
ethane	74-84-0	$\infty$	$\infty$	—
propane	74-98-6	$\infty$	$\infty$	—
i-butane	75-28-5	23,000	7,100	—
2,2-dimethylbutane	75-83-2	5,600	200	n-hexane
i-pentane	78-78-4	59,000	7,100	n-pentane
2,3-dimethylbutane	79-29-8	5,600	200	n-hexane
1t,2-dimethylcyclopentane	822-50-4	3,500	350	propylcyclopentane
2,3,4-trimethylhexane	921-47-1	4,800	450	n-nonane
2,4,4-trimethylhexane	921-47-1	4,800	450	n-nonane
3,4-dimethylheptane	922-28-1	4,800	450	n-nonane
3,5-dimethylheptane	926-82-9	4,800	450	n-nonane
2t-ethylmethylcyclopentane	930-90-5	3,500	350	dimethylcyclopentane, all isomers
1,2-dimethylbenzene	95-47-6	2,200	180	xylene
3-methylpentane	96-14-0	5,600	200	n-hexane
methylcyclopentane	96-37-7	2,600	260	—

## Appendix B-2— Vapor Phase Weight Percentages Summed by Surrogate Group

T=72.1°F (annual modeling)

Surrogate Group	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	MIN	MAX
propane	20.76	32.36	32.40	45.47	36.18	20.76	45.47
n-butane	30.93	24.04	27.32	30.16	26.83	24.04	30.93
n-pentane	21.13	18.63	21.58	16.67	19.09	16.67	21.58
i-butane	14.10	11.72	8.43	8.47	8.94	8.43	14.10
n-hexane	7.00	6.19	7.25	5.81	7.15	5.81	7.25
ethane	0	0.95	2.42	5.08	3.13	0	5.08
n-heptane	2.14	1.99	1.90	1.64	2.12	1.64	2.14
cyclohexane	0.45	1.09	1.30	0.48	1.77	0.45	1.77
methylcyclohexane	0.55	1.28	1.13	0.57	1.61	0.55	1.61
methylcyclopentane	0.45	1.66	1.60	1.19	1.42	0.45	1.66
n-octane	0.71	0.81	0.75	0.67	0.80	0.67	0.81
cyclopentane	0.69	1.00	1.03	0.69	0.60	0.60	1.03
dimethylcyclopentane, all isomers	0.12	0.41	0.39	0.34	0.45	0.12	0.45
propylcyclopentane	0.08	0.40	0.44	0.45	0.43	0.08	0.45
benzene	0.16	0.05	0.29	0.16	0.28	0.05	0.29
1c,3-dimethylcyclopentane	0.05	0.25	0.27	0.25	0.27	0.05	0.27
1t,3-dimethylcyclopentane	0.09	0.28	0.30	0.29	0.26	0.09	0.30
toluene	0.27	0.11	0.22	0.10	0.25	0.10	0.27
n-nonane	0.16	0.23	0.18	0.15	0.14	0.14	0.23
xylene	0.12	0.09	0.07	0.06	0.10	0.06	0.12
n-propylcyclopentane	0	0.05	0.05	0.04	0.06	0	0.06
ethylcyclopentane	0	0	0	0	0.05	0	0.05
i-propylcyclopentane	0.01	0.02	0.02	0.02	0.04	0.01	0.04
ethylbenzene	0.01	0.01	0.02	0.01	0.01	0.01	0.02
3c-ethylmethylcyclopentane	0.001	0.01	0.01	0.01	0.01	0.001	0.01
3t-ethylmethylcyclopentane	0.001	0.01	0.01	0.01	0.01	0.001	0.01
1,1-methylethylcyclopentane	0.001	0.01	0.003	0.003	0.01	0.001	0.01
1-octene	0.001	0.003	0	0	0.002	0	0.003
alkenes, generic, not otherwise specified	0	0.002	0.001	0.01	0.002	0	0.01
i-butylcyclopentane	0	0	0	0	0.001	0	0.001
Styrene	0.001	0	0	0	0	0	0.001

T=95°F (1-hr modeling)

Surrogate Group	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	MIN	MAX
propane	18.98	29.87	30.10	43.67	33.83	18.98	43.67
n-butane	30.27	23.75	27.16	31.01	26.85	23.75	31.01
n-pentane	22.03	19.62	22.90	18.32	20.40	18.32	22.90
i-butane	13.51	11.34	8.20	8.53	8.76	8.20	13.51
n-hexane	7.87	7.03	8.29	6.87	8.22	6.87	8.29
ethane	0	1.16	2.96	6.23	3.82	0	6.23
n-heptane	2.59	2.43	2.35	2.10	2.64	2.10	2.64
cyclohexane	0.53	1.29	1.55	0.59	2.12	0.53	2.12
methylcyclohexane	0.66	1.57	1.40	0.72	2.00	0.66	2.00
methylcyclopentane	0.51	1.91	1.85	1.42	1.65	0.51	1.91
n-octane	0.92	1.06	0.99	0.91	1.07	0.91	1.07
cyclopentane	0.75	1.09	1.14	0.79	0.66	0.66	1.14
dimethylcyclopentane, all isomers	0.15	0.52	0.50	0.45	0.58	0.15	0.58
propylcyclopentane	0.10	0.48	0.53	0.56	0.52	0.10	0.56
benzene	0.19	0.06	0.35	0.20	0.34	0.06	0.35
1c,3-dimethylcyclopentane	0.06	0.29	0.32	0.31	0.33	0.06	0.33
toluene	0.34	0.13	0.29	0.13	0.33	0.13	0.34
1t,3-dimethylcyclopentane	0.11	0.34	0.36	0.35	0.31	0.11	0.36
n-nonane	0.22	0.32	0.25	0.22	0.20	0.20	0.32
xylene	0.17	0.12	0.10	0.08	0.14	0.08	0.17
n-propylcyclopentane	0	0.06	0.06	0.05	0.08	0	0.08
ethylcyclopentane	0	0	0	0	0.06	0	0.06
i-propylcyclopentane	0.02	0.03	0.02	0.03	0.06	0.02	0.06
ethylbenzene	0.01	0.02	0.03	0.01	0.02	0.01	0.03
3c-ethylmethylcyclopentane	0.002	0.01	0.01	0.01	0.01	0.002	0.01
3t-ethylmethylcyclopentane	0.002	0.01	0.01	0.01	0.01	0.002	0.01
1,1-methylethylcyclopentane	0.002	0.01	0.005	0.004	0.01	0.002	0.01
1-octene	0.002	0.004	0	0	0.002	0	0.004
alkenes, generic, not otherwise specified	0	0.003	0.002	0.01	0.002	0	0.01
i-butylcyclopentane	0	0	0	0	0.001	0	0.001
Styrene	0.001	0	0	0	0	0	0.001

## Appendix B-3— Model Results

Surrogate Group	1-hr GLC <sub>max</sub> (µg/m <sup>3</sup> )	1-hr ESL (µg/m <sup>3</sup> )	GLC <sub>max</sub> /ESL (%)	Ann. GLC <sub>max</sub> (µg/m <sup>3</sup> )	Ann. ESL (µg/m <sup>3</sup> )	GLC <sub>max</sub> /ESL (%)
benzene	121.21	170	71.30	0.67	4.50	14.83
n-hexane	2,865.57	5,600	51.17	16.57	200	8.28
methylcyclopentane	660.08	2,600	25.39	3.79	260	1.46
cyclohexane	732.09	3,400	21.53	4.04	340	1.19
i-butane	4,670.99	23,000	20.31	32.21	7,100	0.45
n-butane	10,721.33	66,000	16.24	70.65	7,100	1.00
n-pentane	7,918.60	59,000	13.42	49.29	7,100	0.69
n-heptane	911.78	10,000	9.12	4.90	2,700	0.18
n-octane	368.47	5,600	6.58	1.85	540	0.34
dimethylcyclopentane, all isomers	198.84	3,500	5.68	1.03	350	0.29
propylcyclopentane	194.68	3,500	5.56	1.04	350	0.30
methylcyclohexane	692.94	16,100	4.30	3.68	1,610	0.23
1t,3-dimethylcyclopentane	123.88	3,500	3.54	0.68	350	0.20
1c,3-dimethylcyclopentane	113.11	3,500	3.23	0.62	350	0.18
xylene	58.08	2,200	2.64	0.28	180	0.16
toluene	116.46	4,500	2.59	0.61	1,200	0.05
cyclopentane	392.77	17,000	2.31	2.35	1,700	0.14
n-nonane	110.49	4,800	2.30	0.53	450	0.12
n-propylcyclopentane	27.63	3,500	0.79	0.14	350	0.04
ethylcyclopentane	20.57	16,300	0.13	0.11	1,630	0.01
i-propylcyclopentane	19.74	3,500	0.56	0.10	350	0.03
Styrene	0.26	110	0.24	0.001	140	0.001
3c-ethylmethylcyclopentane	4.76	3,500	0.14	0.02	350	0.01
3t-ethylmethylcyclopentane	3.96	3,500	0.11	0.02	350	0.01
1,1-methylethylcyclopentane	2.45	3,500	0.07	0.01	350	0.004
alkenes, generic, not otherwise specified	3.66	5,700	0.06	0.02	570	0.003
ethylbenzene	9.17	26,000	0.04	0.04	570	0.01
1-octene	1.33	3,400	0.04	0.01	340	0.002
i-butylcyclopentane	0.49	3,500	0.01	0.002	350	0.001
propane	15,101.51	∞	0	103.85	∞	0
ethane	2,154.70	∞	0	11.59	∞	0

## Appendix B-4— Updated Receptor Grid Maps

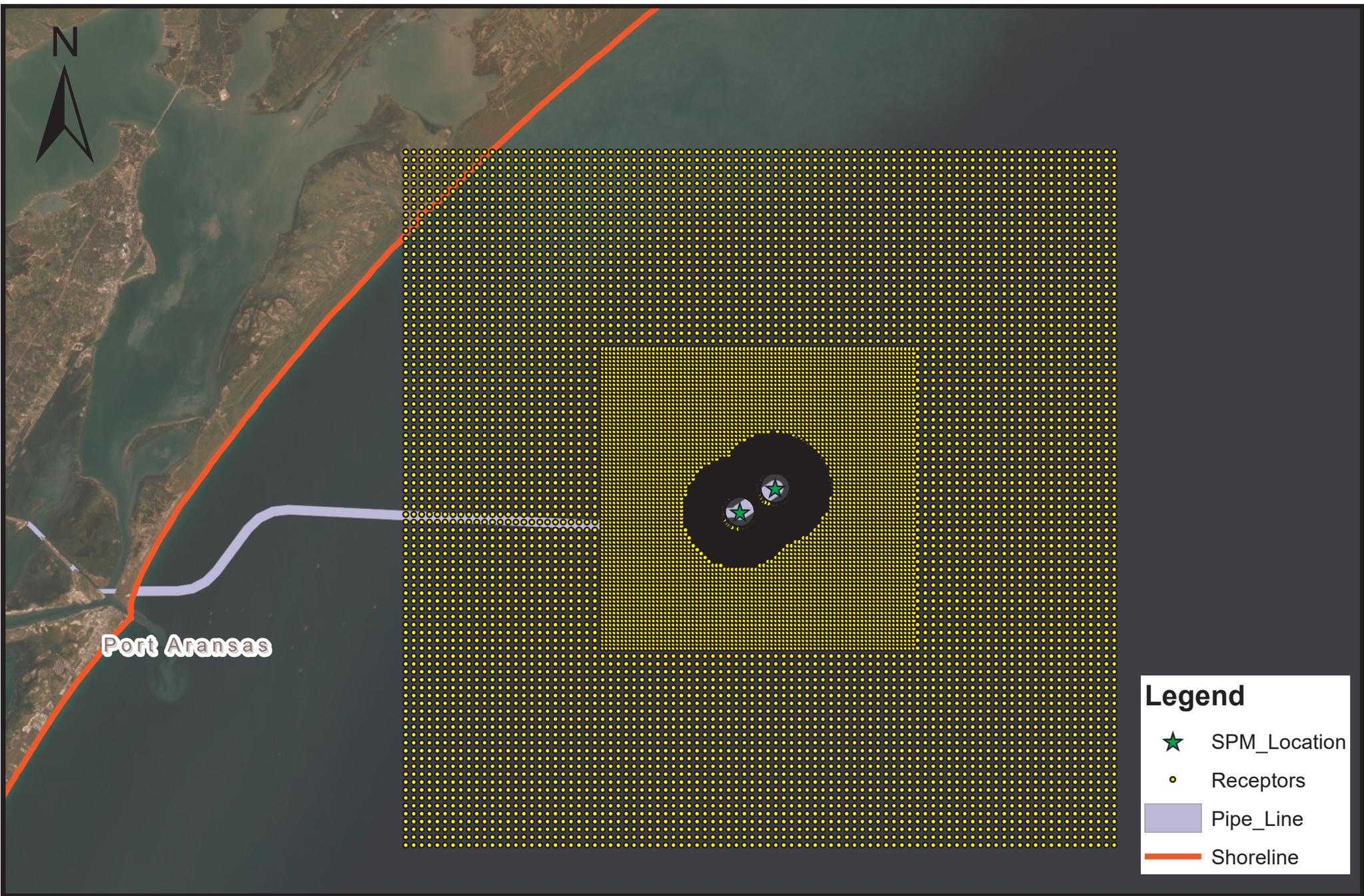
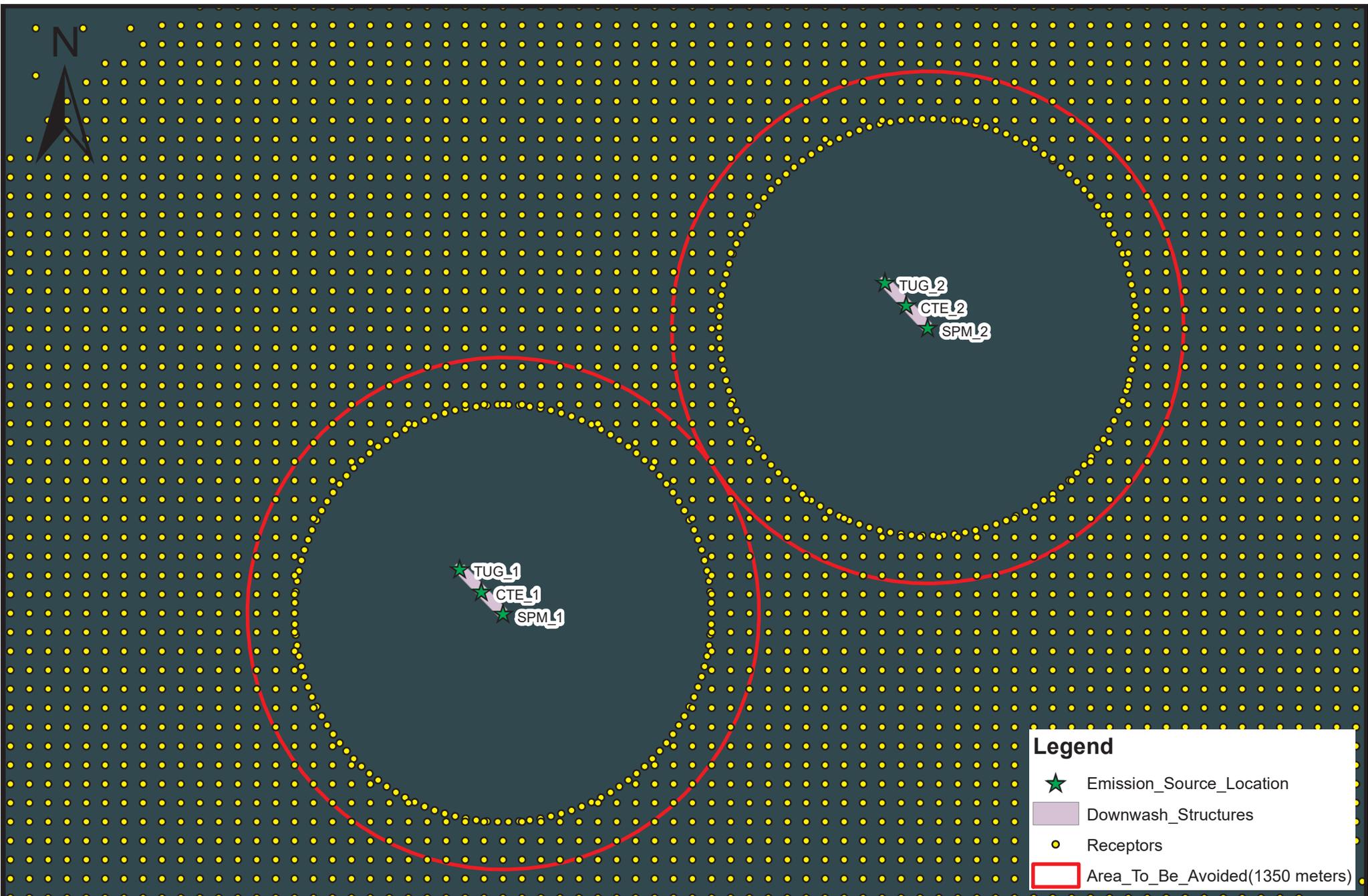


Figure 3-2 Modeled Receptors



**Legend**

- ★ Emission\_Source\_Location
- Downwash\_Structures
- Receptors
- Area\_To\_Be\_Avoided(1350 meters)

0 0.15 0.3 0.45 0.6 Miles

**Figure 3-3 Modeled Sources and Structures**

